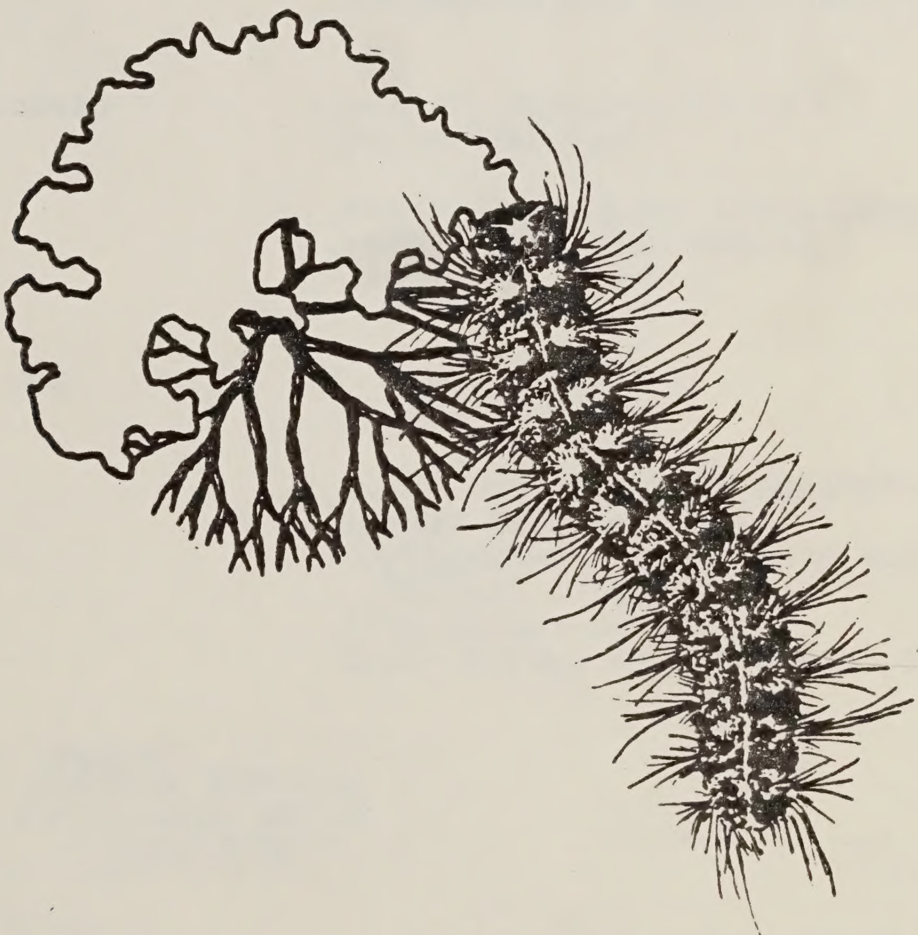
EIS-AA-74-0010-D

Draft Environmental Statement

1974 Cooperative Gypsy Moth Suppression and Regulatory Program



Animal and Plant Health Inspection Service
Forest Service
UNITED STATES DEPARTMENT OF AGRICULTURE

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U. S. DEPARTMENT OF AGRICULTURE

FOREST SERVICE

I. Report Number - USDA-FS-APHIS-DES - 74-58

II. Title 24510 - Environmental Statement on the Cooperative Gypsy Moth Suppression and Regulatory Program - 1974 Activities.

caps proper name prog.?

III. Responsible Officials - John R. McGuire, Chief Forest Service

Frank J. Mulhern, Administrator Animal and Plant Health Inspection Service

IV. Date Field with CEQ - DEC 27 1973

V. Prepared by - U. S. Department of Agriculture Forest Service Northeastern Area, State and Private Forestry 6816 Market Street Upper Darby, Pennsylvania 19082

U. S. D. A. ENVIRONMENTAL IMPACT STATEMENT

Cooperative Gypsy Moth Suppression and Regulatory Program - 1974 Activities

Prepared in Accordance with Section 102(2)(C) of P. L. 91-190

Summary Sheet

I. Draft (X) Final ( )

II. Administrative (X) Legislative ( )

III. The Forest Service and Animal and Plant Health Inspection Service of the USDA cooperate with responsible State agencies for the suppression and/or regulation of the gypsy moth. In 1974 action is probable in the States of Connecticut, Delaware, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, Vermont, and Virginia.

The purpose of the current cooperative suppression efforts of the States and Forest Service using carbaryl, trichlorfon, and *Bacillus thuringiensis* on about 375,000 acres is to protect forests and forest-related resources from imminent damage by the gypsy moth.

The purpose of the cooperative regulatory program of the States and the Animal and Plant Health Inspection Service is to prevent artificial long-range spread of the insect and to eradicate incipient remote infestations within the United States through judicious use of registered insecticides and biological measures.

The impacts, both beneficial and adverse, the alternative actions available, the purposes and objectives of the basic APHIS regulatory and State/Forest Service cooperative suppression programs are discussed in detail in this and previous impact statements and, therefore, will not be repeated in subsequent years. It is proposed that, instead, an annual addendum be prepared that presents only new knowledge, additional alternatives or impacts not previously discussed, and details for implementing the agencies' annual projects under the basic program.

IV. Beneficial effects of the program are to protect forest resources that people value for recreation, esthetics, shade, temperature modification, timber production, to reduce the nuisance of the insect, and to minimize artificial spread.

Adverse environmental effects are discussed, the most significant being potential temporary reduction of certain beneficial insects and soil arthropods. Other effects discussed are judged not significant at the dosage levels proposed.

V. Apparent alternatives considered include use of: acephate, Gardona(R), Imidan(R), leptophos, methoxychlor, Zectran(R), wide-scale spraying, nucleopholyhedrosis virus, sterile males, genetic control, sex attractant, parasites and predators, stand manipulation, and inaction.

VI. Comments on this Draft Statement are requested from:

Federal Environmental Protection Agency
U. S. Department of Agriculture
U. S. Department of Commerce
U. S. Department of Health, Education and Welfare
U. S. Department of the Interior
State Clearing Houses, State Foresters, and State Regulatory Agencies - Connecticut, Delaware, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia
American Forestry Association
Environmental Defense Fund
Izaak Walton League of America
National Association of State Foresters
National Audubon Society
National Gypsy Moth Advisory Council
National Wildlife Federation
Sierra Club
Society of American Foresters
Abbott Laboratories
Chemagro Corporation
Chevron Chemical Company
Sandoz-Wander, Inc.
Union Carbide Corporation

VII. This Draft Statement submitted to the Council on Environmental Quality and available to interested parties after

U. S. D. A. ENVIRONMENTAL IMPACT STATEMENT

Cooperative Gypsy Moth Suppression and Regulatory Program - 1974 Activities

Prepared in Accordance with Section 102(2)(C) of P.L. 91-190.

Type of Statement	Draft
Date of transmission to CEQ:	DEC 27 1973
Type of action:	Administrative
Responsible officials:	John R. McGuire, Chief Forest Service
and	Frank J. Mulhern, Administrator Animal and Plant Health Inspection Service

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CONTENTS

** Topics the Council on Environmental Quality has stated should be included in all Environmental Impact Statements.

V. ENVIRONMENTAL IMPACTS

I. DESCRIPTION OF THE SITUATION

BIOLOGICAL BACKGROUND, HISTORY OF INFESTATION, SUPPRESSION, AND REGULATORY ACTIVITIES.

The gypsy moth, *Porthetria dispar* (L.), is a native of the temperate regions of Europe, southern Asia, and Africa. Over much of its native range, the gypsy moth periodically reaches outbreak proportions and causes widespread defoliation. In a recent survey of five foreign countries (Germany, Yugoslavia, Japan, France, and Romania), all except Germany regarded it as a major problem (Lewis, 1937b)[1/]. The magnitude of the problem is exhibited in Yugoslavia, which is approximately the same size as New York and Pennsylvania, where 7.5 million acres were defoliated in 1965. Romania reported that periodically over 2.5 million acres are defoliated. Schedl (1936) documented the problem and history of the outbreaks in Eurosia and Africa through the early 1930's. These examples demonstrate that the gypsy moth, even in its native habitat is a problem insect periodically reaching outbreak proportions requiring treatment, as has been our experience in the northeastern United States.

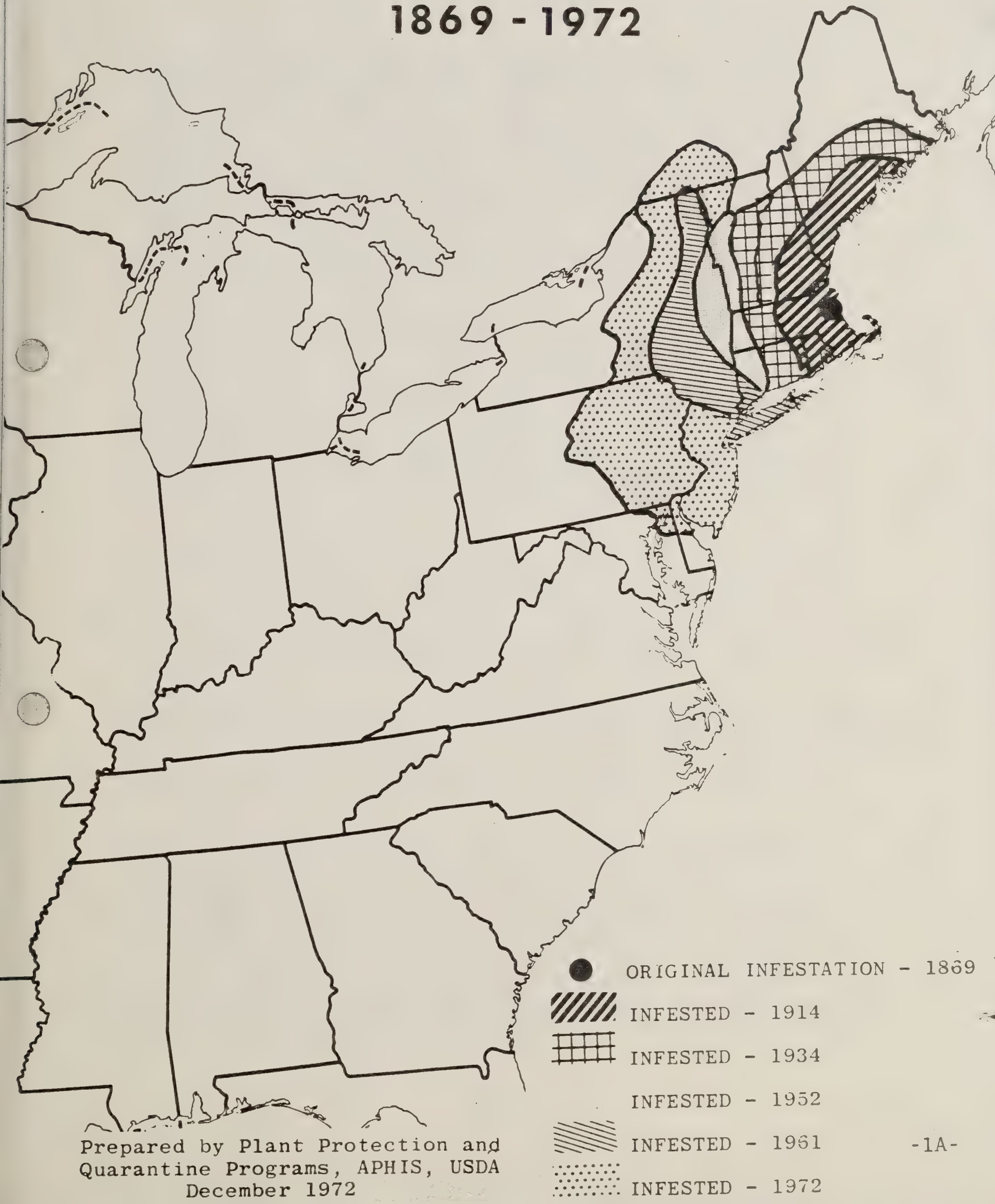
In either 1868 or 1869, the gypsy moth was introduced into North America at Medford, Massachusetts, by a French naturalist who had intended to cross it with the silkworm. The spread of the gypsy moth from that source occurred in two ways--by windblown dispersal of the newly hatched larvae, and by the inadvertent transport of the insect--primarily as egg masses attached to vehicles, building materials, and almost any other movable object. (See map of spread through 1972, p. 1A).

Biological attributes that contribute to the success of the gypsy moth include its great reproductive capacity, its polyphagous habits, and the morphological and behavioral adaptions of the larvae.

1/ Literature is cited by author(s) and year of publication. For complete reference information, see pages 147-170.

GYPSY MOTH SPREAD

1869 - 1972



Prepared by Plant Protection and
Quarantine Programs, APHIS, USDA
December 1972

A gypsy moth egg mass may contain any number of eggs in a wide range, but usually 300-500 eggs, depending upon the age and intensity of the infestation and upon site conditions. Egg hatch occurs in April and May and may extend over a period of 20 to 30 days in any given site. The newly hatched larvae are morphologically and behaviorally well adapted for dispersal (McManus, 1973) and may be carried up to 30 miles by air currents. Therefore, populations are highly unstable until the majority of the larvae reach the second instar. This characteristic of gypsy moth populations has compounded control problems because timing in application of nonpersistent pesticides becomes critical.

Although the young larvae are usually restricted to feeding on a few tree species (mainly oaks), the later-instar larvae (Mosher, 1915) can survive on most forest tree species except a few including ash, tulip-poplar, and sycamore. In light to medium infestations, the instar IV-VI larvae feed at night and descend in the daytime to sheltered spots on the lower bole or in the surrounding litter. In heavy infestations, the larvae remain on the foliage and feed contrinously. (For a brief review of some other behavioral adaptations of the gypsy moth to outbreak conditions, see Leonard, 1971).

The original infestation increased and spread gradually until, by the summer of 1889, the insect became so abundant and destructive that it attracted public attention (Burgess and Baker, 1938). In 1890, the Massachusetts Legislature appropriated money for field operations to exterminate the insect. At this time, the infestation encompassed a 200-square mile area which included 30 towns and cities principally to the north and west of Boston.

Control operations consisted of: (1) applying creosote to egg masses, (2) burning infested trees and shrubbery, (3) banding trees with burlap and sticky materials to either trap the larvae or prevent their ascent of the tree, and (4) spraying with Paris green or lead arsenate (Kirkland, 1905; Burgess, 1930).

From May 1891 to February 1900, the control work was so successful in reducing the infestation that the Legislature chose to abandon the project. During the next five years, populations of the gypsy moth increased tremendously in the old infested areas and spread into areas of Maine, New Hampshire, and Rhode Island. Massachusetts resumed control activities in 1905 and the Federal Government appropriated money in 1906 to help check further spread. Efforts were made to prevent the shipment of infested products into outlying areas. This eventually led to the enactment of the Plant Quarantine Act by Congress on August 20, 1912.

From 1906 to 1912, the Federal Government and Massachusetts jointly financed the importation of natural enemies of the gypsy moth from several European countries and Japan (Brown and Sheals, 1944). The Government took over this work in 1912, but operations were halted in 1914 because of World War I and were not resumed until 1922.

Between 1906 and 1920, the gypsy moth spread westward against prevailing winds at an average rate of six miles a year. Isolated infestations during this period were discovered in 1913 at Geneva, New York, and in 1914 on estates at Cleveland, Ohio, and Westchester, New York. By 1914 the generally infested area included the southern half of New Hampshire, Rhode Island, eastern Connecticut, southern Vermont, and Massachusetts east of the Connecticut River.

In 1920 a serious infestation covering 400 square miles was discovered near Somerville, New Jersey. This resulted from a new introduction of infested blue spruce trees from The Netherlands. This infestation was finally eradicated by 1931 (Felt, 1942).

A meeting was held in 1923 at Albany, New York, between the USDA and respresentatives from infested States and Canada. It was decided to establish a barrier zone extending from Canada to Long Island, largely along the Hudson River and Champlain Valleys, and encompassing some 10,500 square miles. The purpose of the barrier zone was to prevent the westward spread of the gypsy moth through a cooperative effort by the Federal Government and the State of New York. Infested territory to the east of the zone was to be treated by the States and supplemented by the liberation of parasites and other natural enemies by the Bureau of Entomology. All infestations found within and to the west of the barrier zone were to be eradicated.

In older infested areas, conditions had improved by 1920, and in the next four to five years, defoliation in New England was at the lowest level since 1905. However, heavy defoliation occurred on Cape Cod in 1925-26 and the reinfestation of old areas continued so that outbreak conditions prevailed in 1929.

Infestations appeared annually within the barrier zone during the first ten years of its establishment, and these were reduced or eliminated.

However, in 1932 a serious infestation was found in the Wilkes Barre-Scranton, Pennsylvania, area, far beyond the barrier zone. The main infestation covered a 15 square-mile area, but smaller infested spots were later found over a 1,000 square-mile area in five counties.

A cooperative Federal-State eradication effort was begun in 1932, utilizing the same methods used earlier in New England. Although spot infestations were eliminated, the gypsy moth persisted in Pennsylvania. Meanwhile, the barrier zone became generally infested by 1939.

The insecticide cryolite was applied experimentally in Pennsylvania in 1943 against the gypsy moth but gave unsatisfactory control. In 1944, the War Department allotted about 100 pounds of DDT to determine its value in gypsy moth control and eradication work. Pennsylvania was chosen because it represented the southernmost extension of the insect in the United States. Experimentation with DDT in Pennsylvania continued until 1948 and resulted in the development of modern methods of application: airplane spraying and the mistblower. The Pennsylvania infestation was supposedly eradicated by 1948; however, two undetected infestations remained, and the State has been subject to new infestations and continual spread of the gypsy moth since that time (Nichols, 1961).

Gypsy moth infestations seemed to explode in 1951-52, and in 1953 over 1-1/2 million acres were defoliated (25-100%) in the Northeast. Between 1953 and 1957, the insect spread over 9 million previously uninfested acres in New York, Pennsylvania, and New Jersey. In addition, an infestation was found near Lansing, Michigan, and in 1954 it was chemically treated. Over 3 million acres was sprayed aerially with DDT in 1957, and populations receded by 1959-60. Beginning in 1958, the insecticide carbaryl was used increasingly and DDT phased out of cooperative control efforts because of public concern over DDT residues in milk.

The amount of defoliation in the Northeast has increased steadily since 1958, except for a brief reduction in 1966-68. The history of defoliation from 1924 through 1973 is reflected in Table I, which is a record of varying degrees of defoliation. In 1973 there was more defoliation than ever before.

Table 1. Summary of gypsy moth defoliation in acres by States from 1924.

YEAR	MAINE	N. H.	VT.	MASS.	R. I.	CONN.	N. Y.	PA.	N. J.	TOTALS
1924	71	591	-	163	-	-	-	-	-	825
1925	-	239	-	48,321	-	-	-	-	-	48,560
1926	1	960	5	78,193	1,663	-	-	-	-	80,822
1927	4,985	3,923	2	131,880	126	4	-	-	-	140,920
1928	5,575	119,757	3	137,121	58	-	-	-	-	262,514
1929	15,187	440,845	-	95,078	23	-	-	-	-	551,133
1930	55,174	205,125	-	27,856	66	5	-	-	-	288,226
1931	20,938	96,690	277	86,694	114	8	-	-	-	204,721
1932	42,298	43,287	1	200,387	376	46	-	-	-	286,395
1933	19,718	216,669	2	157,003	4,292	46	-	-	-	397,730
1934	60,403	285,880	25	128,237	17,750	66	-	-	-	492,361
1935	92,630	330,195	106	108,097	10,908	833	-	-	-	540,769
1936	80,944	192,114	-	152,469	3,095	-	-	-	-	428,622
1937	140,026	72,973	81	393,613	2,063	4	-	-	-	608,760
1938	120,432	34,122	416	154,348	3,297	1,339	-	-	-	313,954
1939	202,193	136,772	5,311	143,292	848	4,224	-	-	-	492,640
1940	204,041	152,797	3,160	125,586	52	-	-	-	-	485,636
1941	122,386	80,579	980	263,369	707	-	-	-	-	468,021
1942	850	6,963	49	36,715	-	-	-	-	-	44,577
1943	10	290	-	34,481	64	-	-	-	-	34,845
1944	21,221	2,346	210	225,637	640	14	75	6	-	250,149
1945	210,881	58,517	93,950	456,832	1,280	16	-	11	-	821,487
1946	203,813	183,943	15,900	217,132	1,645	486	-	-	-	622,919
1947	-	166	-	7,256	-	-	-	-	-	7,422
1948	60	21	-	32,386	-	-	-	-	-	32,467
1949	-	8	-	78,665	-	-	-	-	-	78,673
1950	2	12	-	4,979	-	375	-	-	-	5,368
1951	8,195	2,478	1,108	3,185	-	5,673	675	-	-	21,314
1952	82,715	94,975	26,985	82,372	-	6,005	-	-	-	293,052
1953	174,999	209,335	120,787	917,996	-	56,215	1,745	-	-	1,487,077
1954	170,485	154,015	24,650	118,095	-	13,848	10,355	-	-	491,448
1955	10,810	14,975	8,875	-	-	6,842	10,559	-	-	52,061
1956	7,285	9,305	12,635	3,830	-	3,458	6,645	-	-	43,158
1957	120	-	495	16	-	4,909	858	60	-	6,458
1958	-	-	-	8	-	117	-	-	-	125
1959	1,000	4,000	1,500	382	-	5,980	1,605	-	-	14,467
1960	6,350	4,600	6,132	150	-	15,000	16,490	-	-	48,722
1961	21,340	621	11,834	3,000	-	(not avl.)	30,685	-	-	67,480*
1962	3,998	3,390	6,292	150,000	-	83,290	61,342	-	-	308,312
1963	1,970	8,345	12,020	87,847	-	40,140	22,600	-	-	172,922
1964	-	14,509	23,523	20,787	375	98,552	97,237	-	-	254,983
1965	190	8,451	2,903	17,232	50	86,009	148,366	-	-	263,201
1966	30	20	650	500	110	15,895	34,655	-	5	51,865
1967	825	561	2	909	150	2,731	46,160	-	1,035	52,373
1968	777	5,830	-	3,925	565	16,416	47,525	60	5,025	80,123
1969	1,450	17,160	-	6,060	313	56,881	121,610	830	51,525	255,829
1970	1,080	38,525	-	6,835	1,082	368,706	416,270	10,500	129,835	972,833
1971	820	3,250	790**	18,787	8,525	655,107	479,150	92,200	180,595	1,439,224
1972	40	200	4,215	20,480	22,510	513,880	177,605	404,060	226,140	1,369,130
1973	490	30	200	43,970	35,925	333,215	248,441	856,710	254,865	1,773,846
	2,118,808	3,260,359	386,074	5,030,156	118,672	2,396,335	1,986,653	1,364,437	849,025	17,510,519

* Exclusive of Connecticut
** Partial survey

Data from Plant Protection & Quarantine, Animal and Plant Health Inspection Service, Moorestown, New Jersey, Sept. 19, 1973.

The rate of spread of the insect to the south and west has exceeded that for any period of time since 1920.

In 1971, 1972 and 1973, three States--New Jersey, New York, and Pennsylvania--sprayed parts of their large gypsy moth infestations in a cooperative suppression effort with the Forest Service. Rhode Island joined the other three in 1973. The objective was to reduce damage to forest resources that are particularly valuable. The insecticides carbaryl, *B.t.*, and trichlorfon were applied. The data in Tables 2 and 3 indicate the nature and size of the cooperative suppression work.

Table 2. Acreage and number of blocks treated for the gypsy moth in 1971, 1972 and 1973, in cooperative efforts to reduce forest resource damage.

State	Acreage Sprayed			No. of Spray Blocks		
	1971	1972	1973	1971	1972	1973
New Jersey(Agric.)	54,029	47,412	47,443	204	173	157
" (Env.Prot.)	19,873	2,760	2,356	8	3	6
New York	241,000	41,279	14,870	129	97	105
Pennsylvania	20,400	20,400	41,128	18	41	150
Rhode Island	-	-	67,773	-	-	25
Totals	335,302	111,851	173,570	359	314	443

Table 3. Percent of total potential defoliated area sprayed in the 1971-1973 cooperative suppression program.

State	Percent of area sprayed		
	1971	1972	1973
New Jersey	29	18	16
New York	33	19	6
Pennsylvania	18	5	5
Rhode Island	-	-	65

To cope with the artificial spread of the gypsy moth, the Animal and Plant Health Inspection Service sprayed infested campgrounds and mobile home sites in nine northeastern States in 1971, 1972, and 1973. This work, carried out in cooperation with the States infested, is reflected in Table 4. Also, to prevent natural spread from outlying infestations in Michigan and Ohio, and to try to eliminate them, those States and the Animal and Plant Health Inspection Service in 1973 sprayed 13,366 acres in Michigan and 335 acres in Ohio.

Table 4. Acreage and number of blocks treated 1971-1973 in cooperative efforts to reduce artifical spread of the gypsy moth.

Year	Acreage Sprayed	No. of Spray Blocks
1971	20,394	308
1972	30,473	400
1973	32,115	623

Together, these tables illustrate the policy followed currently in cooperative State/Federal gypsy moth control : treatment is limited to high-value areas or to areas most likely to permit long-range spread. Typically, widespread application of pesticides is not carried out. In Rhode Island, the obvious exception, the forest resource values practically everywhere are high and the State finds the dollar and manpower resources needed to treat a larger proportion of the total area. Neither there nor elsewhere, however, is there a massive effort to "break the back" of the outbreak, halt or minimize natural spread from the generally infested area, and there is no effort to eradicate the insect from the United States.

IMPACTS OF GYPSY MOTH OUTBREAKS

The best-documented impacts of gypsy moth outbreaks are those recorded for trees. There is considerable information on tree mortality, lost growth in trees, and changes in forest stand composition but less information on impacts on birds, fish, other wildlife, soil, water, and other plants besides trees.

On Trees. Impacts discussed here all derive from defoliation. Not all tree species are attacked by the gypsy moth. Caterpillars of the insect exhibit feeding preferences, which were documented years ago (Mosher, 1915).

Preferred hosts of the gypsy moth include apple, aspen, beech, white, gray and red birch, larch, linden, oaks, and willows. Older larvae feed readily also on hemlock, pines, and spruce. Less preferred but edible are black and yellow birch, Norway, red, silver and sugar maples, cherries, elm, hickories, and pear. Least favored plants include ashes, balsam fir, butternut, walnut, cedars, dogwood, elder, mountain laurel, locusts, mountain and striped maple, sycamore, and tulip-poplar.

The impact of defoliation on forest trees can be estimated by measurement of tree mortality and loss in radial growth. Changes in forest stand composition also result from defoliation, mortality and reduced growth. The significance of these changes and losses depend on people's value judgments, which are difficult to quantify.

Tree Mortality. The death of trees following gypsy moth defoliation has been studied in detail (Baker, 1941; Tierney, 1947, Crossman, 1948; House, 1960; Turner, 1963b; Campbell and Valentine, 1972).

House (1960) in New England recorded results five years after a single heavy defoliation. For oaks he estimated 5% mortality in trees defoliated 90% or more, not unlike normal attrition that occurs in heavily stocked stands. Kegg (1972b) found that the two years of heavy gypsy moth defoliation observed in 1969 and 1970 in northern New Jersey killed 63% of the oaks in the area studied. In another part of the State in a stand where the proportion of oak was lower, he found 28% mortality of the oaks following repeated defoliation (Kegg, 1971b). Turner (1963b) cited a study made by Tierney (1947) in western Massachusetts. In 1947 Tierney estimated mortality of oaks after 13 years in plots that varied widely in degree of defoliation and history of attacks. Turner summarized the findings by stating: "About two-thirds of the acreage showed from 10-50% mortality, and one-third 40-75%." Turner (1963b) cited estimates made by Crossman (1948) of the oak mortality resulting from gypsy moth outbreaks over some 55,000 acres in Maine, Massachusetts, and New Hampshire. For this area he quoted Crossman as reporting: "All of this dying is not recent and in many cases it goes back at least 20 years and is scattered throughout entire

townships. From 25 to 50 percent of the oak is dead on a large part of the acreage mentioned above and in many small pockets it ranges from 75 to 100%, scattered throughout the area. Without the injury due to gypsy moth the trees would not have died, and it is probable that in many cases other factors contribute to the injury, such as climatic conditions, frost, lack of moisture, poor soil, the two-lined chestnut borer, and unknown factors."

From a ten-year study in the same area, Baker (1941) was able to show that there is a correlation between mortality and defoliation. One year after a single defoliation, mortality ranged from 4% for trees not attacked to 10% for those heavily defoliated; this was the relationship for the combination of 29 species of trees in the study. Both mortality and defoliation were higher in the tree species that are the favored food of the gypsy moth. The favored food trees experienced 30% mortality, the less favored 13%. Defoliation of the favored food trees averaged 37% for the ten years, that of the less favored 10%.

The hypothesis that mortality and defoliation are correlated was confirmed in a more recent report. In a study of long-term records in Connecticut, Stephens (1971) concluded that in terms of a decade a single defoliation may not increase mortality. Also, repeated defoliation will cause not more than a doubling of the mortality that would otherwise be expected in Connecticut. His observations substantiate the opinion stated nearly 20 years earlier by House (1952), which he quotes: in Connecticut and Rhode Island mortality caused by the gypsy moth is less because there "a degree of resistance exists which even in years of heavy buildup causes mortality losses to be considerably under the average for other areas of New England."

The order of hardwoods susceptibility to mortality from gypsy moth defoliation has been presented by Stephens (1971), Kegg (1971a and 1971b) and Campbell and Valentine (1972). White and chestnut oaks are most susceptible, followed by gray birch and red-oak-group trees (black, northern red, and scarlet oaks), then red maple, other birches and hickories.

Hemlock can suffer heavy mortality from a single severe defoliation (House, 1960; Kegg, 1971a), as does young eastern white pine (Baker, 1941; House, 1960).

Stephens and Hill (1971) studied changes during 1959-1970 in Connecticut forests and found that drought appeared to have little effect on mortality rate. Repeated defoliation increased overall mortality on all but poorly drained soils. The mortality rate of oak increased by 50% following repeated defoliation. They emphasize the importance of defining losses as reflecting the short run or a long period. "If great losses were sustained during the year or two immediately following defoliation, subsequent mortality might be reduced below normal because of the thinning of the forest. By the end of the period, however, the average might be little different from normal. For example, if a species normally loses 20% of its stems during a decade, or 2% annually, but suddenly at the midpoint loses 5% annually for two years and 1% thereafter, the loss for the decade is 23% or 2.3% annually. Average annual death is little changed despite greater losses immediately after defoliation. We know that oak mortality increases after repeated defoliation. However, only annual observation will determine whether mortality increases sharply and then subsides or whether it varies less dramatically over a longer time."

A very recent contribution to the subject of gypsy moth damage is a publication by Campbell and Valentine (1972). They have compiled tables that present data analyzed in many ways. The tables can be used for predicting mortality. Data for the analyses is that which was taken for up to 20 years from the 264 plots established during 1911 and 1912 in Maine, New Hampshire, and Massachusettes. That same data has served as the basis for several other important reports, notably those by Baker (1941) Minott and Guild (1925), and Baker and Cline (1936). The area in which the plots were located was reported on by Crossman (1948).

Campbell and Valentine were able to combine their insights with what the earlier workers did not have--electronic data processing--to cope with the mountain of data from the plots. Most of the infested stands sampled by the 264 plots were typified by oaks, gray birch, some red maple, and white pine. Data from 121 of the 264 original plots show that after 12 years, including 2 consecutive years of heavy defoliation on most plots, tree losses averaged 58% for white oak, 55% for gray birch, 46% for both black and scarlet oaks, 27% for red oak, and 26% for red maple. Mortality rates for all species tended to be highest among suppressed trees and lowest among dominant trees. Trees more vigorous before defoliation had a lower incidence of mortality. The mechanisms by which defoliation causes impact on trees are becoming clearer as research progresses. Root systems may deteriorate after two or more severe defoliations (over 80% loss of foliage) and result in crown deterioration. Also, investigation is revealing that defoliated trees are pre-disposed to attack by root-disease pathogens, particularly the shoe-string root rot fungus, *Armillaria mellea* (Staley, 1965).

Radial Growth Loss. A reduction in radial growth also is associated with defoliation by forest insects (Kulman, 1971). Reductions from 15 to 67% were observed following severe gypsy moth outbreaks in Europe (Mirkovic and Miscevic, 1960; Kondakov, 1963). Turner (1963b) cited House (1960) as stating that growth loss was appreciable only on trees that were at least 80% defoliated. In oaks, growth loss was 24% in the year of defoliation and 28% a year later. Five years after 100% defoliation, red and white oaks averaged 7% net annual growth loss. Minott and Guild (1925) found that the defoliation rate of red, scarlet, black and white oaks over a ten-year period averaged 37% and the growth reduction averaged 38% when compared to the predefolition decade. They concluded that radial growth loss very closely approximates degree of defoliation. Kulman (1971) cited Hungarian studies on several species of oaks, where three to four years of complete defoliation reduced annual growth by more than 50%. Baker (1941) also found a direct correlation between percentage defoliation and radial growth reduction in four species of oak.

In conifers, radial growth loss can be measured in the hardier trees that are able to survive defoliation. Baker (1941) found that heavily defoliated (60-100%) eastern white pines had only half the radial growth of pines in the 0-20% defoliation category after a 10-year period of repeated attacks. In his study of eastern white pine, House (1960) also gained information on hemlock. Trees defoliated 80% or more lost radial growth that year; in white pine growth was 14% less than the year before, in hemlock 40%. A year later the loss was 25% in white pine and 27% in hemlock. In the five years following one complete defoliation, white pine trees lost an average 16% of their growth annually, and hemlock lost 28% annually.

Changes in Forest Stand Composition. Information on the effect of insect defoliation on future stand composition is not abundant. The analyses by Campbell and Valentine (1972) indicate that gypsy moth defoliation tends to accelerate the decline of pioneer birch stands, reduce the ratio of white oak to red oak, and to increase the white pine component in mixed stands. Stephens (1971) learned that in Connecticut defoliation increased the mortality of oak but hardly affected maples (red and sugar) and birches (black and yellow). "Loss of oak stems was proportionally greater than loss of maple or of all major species." He judged this could be evidence of a gradual change in forest composition. The work of another Connecticut investigator helps to explain how defoliation by the gypsy moth benefits red maple in the understory (Collins, 1961). Two mechanisms operated to achieve what he observed. One - increased light intensity resulting from the defoliated oak overstory - caused maple stems to elongate over a longer time period than they would have under a closed canopy. The other - increased nutrients from frass manufactured at the expense of oak - probably (in the judgment of Collins) was responsible for the increased survival rate observed in understory maple in the years immediately following overstory oak defoliation. The value of frass for understory plants has not been defined, but some people are convinced that its value is high - Clement and Nisbet (1972), for example.

Bess, Spurr, and Littlefield (1947) pointed out that the climax and sub-climax forests of the Northeast are resistant to heavy defoliation by the gypsy moth. Pioneer forests and forests abused by man are set-backs in forest succession and contain those conditions making them susceptible to heavy defoliation by the gypsy moth. They stated, "The moth itself markedly influences forest succession, thus affecting stand susceptibility over a period of years." It can do this in two ways, they said. Through "moderately heavy" defoliation the insect hastens the death of short-lived weed trees and otherwise reduces the proportion of favored food in forest stands. On the other hand, "frequent severe defoliation will generally create conditions highly favorable to future epidemics. The stand will be opened up, the litter will dry out, and forest succession will be set back."

A spectacular set-back in succession in New Jersey was reported by Kegg (1972a): "The damage was so extensive on the watershed and so many trees died, that annual grasses and weeds came in in the understory." Reporting earlier on this same Newark watershed, Kegg (1971a) wrote, "It is believed that the first 'wave' of gypsy moth through this forest had the greatest impact in terms of tree mortality and any future outbreak will have a lesser effect on the forest because of the drastic changes in tree species composition tending toward the less preferred hosts."

Thus, defoliation by the gypsy moth has a significant impact on the forest community through a series of complex interactions. Some trees are killed, some are weakened, and radial growth is slowed. In some areas and under some forest conditions this may be sufficient reason to control the gypsy moth. Studies are in progress to develop methods for quantifying these impacts.

On Other Forest Resources. Impacts of gypsy moth outbreaks are caused by caterpillars and frass, defoliation, and the results of defoliation which include: tree mortality, reduced growth, and changes in forest stand composition. Reports on this subject are very limited.

Those who have experienced gypsy moth outbreaks are familiar with the contrast between the conditions prevailing in heavily defoliated forest and the cooler, moist greenness of stands not attacked. In one recorded case of such a contrast, an investigation demonstrated that forest insects were far more abundant in the green forest than in study areas heavily defoliated (Brues, 1947). Forest insects, which are animals of the forest, find in those wooded areas the food, shelter, temperature, and moisture conditions that sustain them. When those conditions to which they are adapted are removed, the insects should emigrate, perish, or live on under stress. Many other animals besides insects are adapted to green forest conditions; they, too, should be expected to experience gypsy moth defoliation as an unfavorable force in their environment. Field observations by gypsy moth workers and other outdoor observers provide some information.

Bird behavior in outbreak areas has not been adequately investigated. A few observations, however, have been recorded by bird watchers in Audubon Field Notes and its successor, American Birds (Dewire, 1972; Magee, 1971a and 1971b; Moseley, 1971 and 1972; Palmer, 1972a and 1972b; Schwalbe, 1970 and 1972). The reports reveal there were no significant changes in observed bird population levels as a result of defoliation by forest insects. Bird census data recorded in Connecticut, Massachusetts, and Pennsylvania during outbreaks of the gypsy moth and/or elm spanworm (*Ennomos subsignarius*) reveal a slight influx of more predaceous (insectivorous) bird species such as cuckoos and woodpeckers. These immigrating birds displace some of the less predaceous songbirds, such as sparrows. Such displacement has a negligible effect on community stability; it is only temporary, too, lasting only until the insect outbreak declines. There are occasional reports indicating more drastic effects, such as a report of death to fledgling robins (Kegg, 1972a).

Forests attacked by the gypsy moth and sustaining mortality, reduced growth, and changed species composition present to forest animals conditions modified from those prevailing before attack. Reason dictates that these changes produce impacts on forest animal populations. No investigations have been made to quantify these effects, which are bound to be a mixture of effects both favorable and unfavorable.

Streams shaded by forest trees are inhabited by aquatic plants and animals. Defoliation removes the shade from those streams, producing light and heat greater than the average to which the aquatic life is adapted. In the year of defoliation that situation lasts until the trees refoliate. Under conditions of successive defoliation those conditions, changed only temporarily the first year, may become more permanent characteristics of the streams, through tree mortality and changed tree species composition.

Something else affects streams and other bodies of water in forests - the frass excreted by larvae of the gypsy moth. Frass is considered both nutrient dump and water pollutant. Observations on the impact of frass are scarce. One report of an observation (Turner, 1963a) stated: "Heavy defoliation produces hundreds of pounds of frass which soon is washed into the water by rain. The effect on the quality of water is immediate in small reservoirs. Moreover, the nutrient elements in the frass increase the growth of algae in water, creating an additional problem of longer duration." A similar observation was reported more recently for New Jersey reservoirs (Kegg, 1972a).

The impacts of the gypsy moth on two other forest resources - soil and plants other than trees - are undefined. Defoliation and tree mortality open the forest floor to unaccustomed heat and light that produces change in forest soil and in plants on the forest floor (Bess et al., 1947; Kegg, 1972a).

On People. Gypsy moth outbreaks affect people directly in two major ways: great numbers of caterpillars and their frass enter man's immediate surroundings, and caterpillars remove the leaves from trees that he values.

Impacts of Caterpillars and Frass. In man's use of the forest he may meet the caterpillars and frass of the gypsy moth. Generally the encounter drives him indoors, abandoning for some weeks his picnic tables and outdoor grills, even his gardening. Any house painting is out of the question in outbreak areas as caterpillars wander over homes, congregating in sheltered places : under window ledges, porch roofs, door sills, eaves, and the like. The caterpillars take their positions daily, migrating back up the trees around dusk.

Natural control forces may result in virus disease sweeping through these larval populations, killing large numbers. The disease-killed caterpillars hang from their sheltered places on houses; their bodies rupture and the rotted fluid contents spill out, staining homes. Bacteria grow in the fluid, making the stench of a diseased population detectable from a distance.

Outdoors, sidewalks are avenues for migrating larvae. Man trying to use those surfaces steps on caterpillars. The feeling is unpleasant, as is the resultant mess. Sidewalks grow stained and caked with the remains of trampled caterpillars. Crushing them makes sidewalks slippery as well as unsightly. Parents may be understandably reluctant to let their children outdoors in gypsy moth outbreak areas.

Caterpillars migrate also over driveways and roads. Vehicle traffic in an outbreak area can make roads slippery and dangerous. People have seen highway department trucks sanding unsafe roads in July in the Northeast.

Gypsy moths invading homes can seriously affect people with a natural fear of insects. Some people have actually cut down all trees on their property to avoid the nuisance of the insect. Others have been denied the use of summer homes during the period in which caterpillars are feeding.

Impacts of Defoliation. It is hard enough for people to live with the caterpillars and frass of a gypsy moth outbreak. Yet they must also endure the experience of having the trees around them stripped of their leaves. Two important impacts resulting from that defoliation are reduced benefits from the trees and reduced enjoyment from the trees. The two blend into one another, but it is convenient for discussion to treat them as though they were separate entities.

The direct benefits man derives from his trees that are in full foliage include cooling and humidifying effects, shade, reducing the level of sound, providing privacy, and sheltering from wind. People take these benefits for granted, as they do their own good health. It is when the leaves have been taken away that man realizes most clearly the benefits trees provide him.

Gypsy moth defoliation drastically alters the forest homeowner's environment. His purpose for living among trees is to enjoy them; robbed of that enjoyment by the gypsy moth, such a person finds a sudden lack in his life where he had experienced fulfillment.

PRESENT SITUATION

<u>Statement of Insect Problem.</u> Gypsy moth populations have increased greatly in the Northeast since 1968, as indicated by defoliation records. One and three-fourths million acres (about 2,800 square miles) were defoliated in 1973, more than ever before. Study of Table 1 reveals this recent spectacular defoliation fell mainly in States only recently invaded by the gypsy moth (New Jersey and Pennsylvania) and those with a long history of relatively small outbreaks (Connecticut, New York, and Rhode Island). Thus, both the great extent and intensity of defoliation is new in these States. In Maine, Massachusetts, and New Hampshire - those States where defoliation and damage were high for many years - defoliation in 1971 and 1972 was extremely low. Except for Massachusetts, this held true in 1973, too. The location of defoliation recorded for 1973 is presented in the map on the following page.

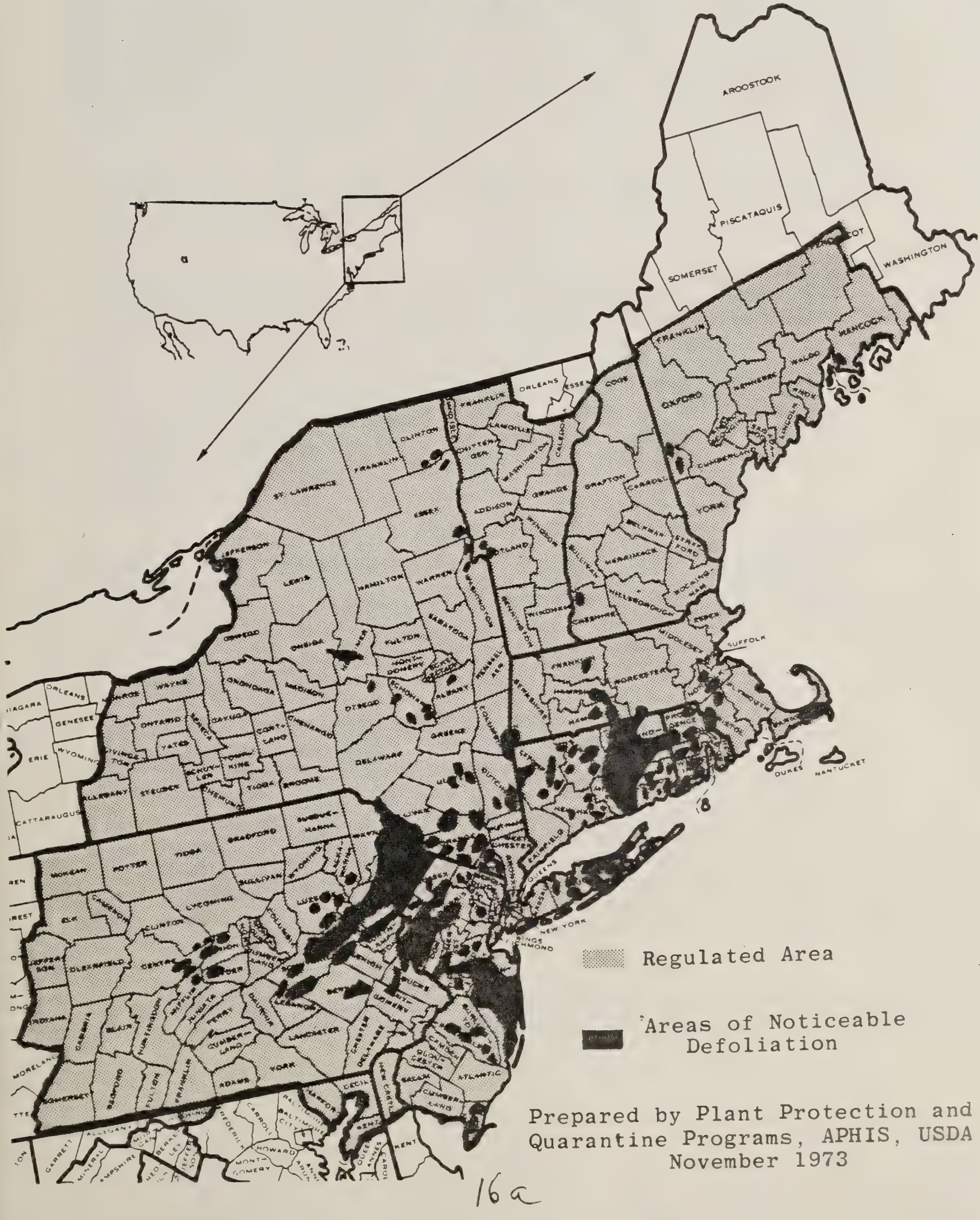
The following table (Table 5) of 1973 defoliation shows broad categories to help understand the significance of the attack record. The categories are rough estimations of intensity, presented this way only to permit an approximation of what the defoliation means.

Table 5. Gypsy moth defoliation recorded by States in 1973.[1/]

	Acres Defoliated			
	Categories of Defoliation			Total
	(Up to 30%) Light	(30-60%) Moderate	(60-100%) Severe	
Maine	-	400	90	490
New Hampshire	-	30	-	30
Vermont	-	200	-	200
Massachusetts	11,520	23,215	9,235	43,970
Rhode Island	6,140	16,110	13,675	35,925
Connecticut	7,514	296,974	28,727	333,215
New York	79,755	52,775	115,911	248,441
Pennsylvania	-	181,775	674,935	856,710
New Jersey	55,740	140,580	58,545	254,865
Totals	160,669	712,059	901,118	1,773,846

1/ Data from Animal and Plant Health Inspection Service, Moorestown, New Jersey, September 19, 1973.

GYPSY MOTH DEFOLIATED AREAS
1973



Prepared by Plant Protection and Quarantine Programs, APHIS, USDA
November 1973

"Light" defoliation signifies noticeable numbers of caterpillars and frass but fairly normal-appearing foliage. Trees with "moderate" defoliation would have noticeably thin crowns, probably thin enough to interfere with their appearance; and caterpillars would be abundant. The "severe" category signifies that tree mortality may occur, caterpillars will be pests, and esthetic values cannot be appreciated until after the trees put out new leaves.

Another way the impact of the present outbreak can be understood is to view it today in relation to the history of defoliation in some of the individual States.

Connecticut was generally infested by 1922, but the first defoliation of any size was not observed until 1935 (Friend, 1945). Outbreaks in 1938-1939 and 1953-1954 were still rather small. Workers suggested that after its many years of relative stability in Connecticut, the gypsy moth would not become as injurious as it had been in Massachusetts in the early 1900's (Friend, 1945; Bess, 1961). Then came the outbreaks that began in 1962. Acreage defoliated in 1971 and 1972 (a result of outbreaks of both the gypsy moth and elm spanworm) exceeded each year that ever recorded in any other State, with just one exception - Massachusetts in 1953.

New Jersey and Pennsylvania are the most recent States to become generally infested. They represent the southern penetration of the gypsy moth invasion. There fringe populations built up rapidly to outbreaks, due probably to the combination of an abundance of favored food and a low level of control by natural enemies. Tree mortality is increasing in both States, with the New Jersey impact probably two years ahead of Pennsylvania, because of its earlier outbreak conditions.

From 1932 to 1968, Pennsylvania had been successfully eliminating or reducing isolated infestations of the gypsy moth so that annual defoliation never exceeded 60 acres. Then defoliation exploded from 800 acres in 1969 to 92,000 in 1971 and 850,000 in 1973. The insect has spread rapidly westward as evidenced by results from the male-moth trapping program of the State and the Animal and Plant Health Inspection Service. In 1971, for example, male moths were found for the first time in over 50 townships. In 1972, recoveries were made for the first time in 13 new counties. The eastern half of the State now is considered generally infested, and scattered infestations apparently exist in the western half.

In New York defoliation remains extensive : nearly a half million acres in 1971, over 175,000 acres in 1972 and roughly 250,000 acres in 1973.

The insect is established on over five million acres. A tough battle was fought in eastern New York for nearly 15 years to stop the insect from moving southward and westward into the States not infested. Movement into western New York has occurred. Male moths were found in eight new counties in 1972; those included the counties farthest west. By the end of 1973 the gypsy moth had been found in every county.

In Massachusetts the pattern of defoliation has changed dramatically since the early years of infestation. A glance at the defoliation record for the past 30 years in that State and in New Hampshire and Maine, reveals a long history of large outbreaks and in recent years comparatively limited defoliation. Some workers suggest that these three States may represent the only situation where a degree of stability or natural control exists between the gypsy moth and its environment. Theories to explain this are numerous and will be advanced as soon as someone demonstrates that the apparent stability is a reality.

Spread of the gypsy moth in the United States was undoubtedly impeded by the Plant Quarantine Act of 1912 and the establishment of a barrier zone in 1923. But the Animal and Plant Health Inspection Service, working with the States involved, has revealed a recent increase in the rate of spread as evidenced by the records for male-moth catches in more southern areas. In Delaware, for example, male-moth catches in 1971 increased sixfold. Multiple catches in Maryland that year were made in all but two western counties. Virginia in 1971 recovered males at more locations, and recoveries were made for the first time in Alabama, the District of Columbia, North Carolina, Ohio, South Carolina, and Wisconsin. An intensive trapping program in 1972 recovered male moths in North Carolina, Ohio, South Carolina, and Virginia. States making their first recoveries were Iowa, Michigan, Tennessee, and West Virginia. In most cases, these captures consisted of single males at isolated locations. However, in Michigan a several-thousand acre infestation was discovered. Many of the captures were close to areas associated with the movement of campers or recreational vehicles.

In recent years widespread use of mobile homes and camper trailers has increased the threat of possible long-range artificial spread of the insect. Campers provide families freedom and mobility, but at the same time they represent a hazard when moved from infested campsites to uninfested areas. Egg masses attached to these vehicles constitute a real threat of spread of the insect. Although other life stages, including late-instar larvae and pupae, also may be transported, they consitute less of a hazard than egg masses.

Regulatory measures during this period of widespread outbreaks have been altered and strengthened to cope with this added problem of recreational vehicles. Heavily infested mobile home parks and recreation areas are monitored and, wherever possible, are treated to reduce infestations. Aerial or ground spraying with carbaryl has been employed for this purpose. In the case of mobile homes where severe infestation conditions exist, these vehicles are visually inspected and all evidence of infestation is removed. Even with a thorough inspection, it is impossible to ensure that a vehicle is pest free. For mobile homes from hazardous parks, inspection personnel in the States that are destinations for the vehicles are alerted to monitor and again inspect for infestations.

One can speculate that, as the gypsy moth is introduced into new areas to the south and west, it will be successful because of an abundance of favored food and a relatively low degree of natural control exerted by native parasites and predators. Apparently no climatic or geographic barrier exists to inhibit the spread of the species. An extensive investigation revealed that the gypsy moth might eventually extend its range in this country to include over 100 million acres, since an abundance of dry and relatively poor sites occupied by oak stands prevail in the southern Appalachians, in the unglaciated areas of the Midwest, in central Tennessee, and in the Ozarks (Perry, 1955). Such conditions are highly favorable to the gypsy moth (Bess et al., 1947).

The Human Response. The States have been strongly encouraged by certain sectors of the public to treat the gypsy moth in selected areas. Some individuals and groups feel that heavy gypsy moth populations need spraying. The motives and reasons for desiring treatment vary, but the desire to suppress gypsy moth populations and to prevent the resultant damage to forest values is strong.

Another portion of the public is opposed to treatment under existing conditions. Their reasons vary, but certain objections are frequently voiced. Generally, there is concern as to whether the gypsy moth is causing sufficient damage to warrant the introduction of a pesticide into the environment.

Both types of human response are complex and may best be viewed as only two points on a broad spectrum of public opinion. There is much to learn about human interest in and response to the gypsy moth and to suppression programs.

The Dilemma. The dilemma facing the public and its officials is a need to balance resource losses against the adverse effects resulting from treatment to prevent such losses. Implied assumptions are many. The damage by the insect must be defined and quantified where possible. The effectiveness of the treatment material and method must be known. The adverse effects of the treatment need to be known, too. Considerable knowledge is available, but additional information will be needed in years to come. Such information, as it accumulates, will improve our understanding of the forest-gypsy moth-human interface each year. It is upon this complex mix of biological and sociological phenomena that this Environmental Impact Statement is focused.

II. PROPOSED ACTION

AGENCY OBJECTIVES AND ACTION POLICIES

The objective of the Forest Service in all its authorized activities relating to control of forest insects and diseases is to: reduce damage and loss caused by insects and diseases on all forest lands to levels commensurate with forest resource and environmental values involved. This objective holds true for gypsy moth as well as all other forest insects and diseases. In implementing this objective, the Forest Service: 1.) works with and through the State agencies having insect and disease control responsibility; 2.) supports State-proposed suppression projects that are based on biological, cost-benefit, and environmental evaluations; 3.) supports the concept that protection of non-federal forest lands is primarily a State responsibility; 4.) provides technical assitance and financial support to State organizations; 5.) provides detection and evaluation services and technical assistance in all phases of forest insect and disease control work on federal land.

The objective of the cooperative regulatory program of the States and APHIS is to prevent artificial long-range spread of the insect and to eradicate incipient remote infestations within the United States through judicious use of registered insecticides and biological measures.

The purpose of the cooperative program is to protect forest and forest-related resources from damage; provide foliage protection; to maintain tree vigor in the areas where tree values are judged to be high for recreational, esthetic and similar purposes; and to reduce nuisance. The purpose is not to "break the back" of the outbreak or to halt or minimize natural spread from the generally infested area; and there is no effort to eradicate the insect from the United States.

The annual Gypsy Moth Environmental Impact Statements recently have contained essentially the same information. It is proposed that this Environmental Impact Statement serve in coming years as the basic document that describes and discusses the Forest Service and APHIS cooperative suppression and regulatory program : its environmental impacts, alternatives, purposes, and objectives - which are expected to remain essentially unchanged for some time to come. In 1975 and in each succeeding year only an addendum would be issued to describe the activities proposed for that year and to incorporate significant changes, modifications, control techniques or strategies, additional alternatives, or impacts not previously discussed.

PROPOSED SUPPRESSION PROJECTS (FOREST SERVICE)

The aerial application of insecticide has been proposed for treatment of certain high-value and high-use State and private lands infested by the gypsy moth in New Jersey, New York, Pennsylvania, and Rhode Island. The proposals are outlined in Table 6.

Table 6. Proposed cooperative gypsy moth suppression projects for 1974.

State	Acres to be Sprayed	Insecticide Active Ingredient	Formulation	Lbs. Active Ingredient/Acre
New Jersey				
Dep. Agr.	58,000	Carbaryl	Sevin 4 Oil	One
" "	2,000	*B.t.* 1/	Dipel or Thuricide	N.A. 2/
Dep.Env.Prot.	15,000	Carbaryl	Sevin 4 Oil	One
New York	53,700	Carbaryl	Sevin Sprayable	One
	2,000	*B.t.*	Dipel or Thuricide	N.A.
Pennsylvania	106,000	Trichlorfon	Dylox 1.5 Oil	One
	44,000	*B.t.*	Dipel or Thuricide	N.A.
Rhode Island	95,000	Carbaryl	Sevin 4 Oil	One
Total	375,700			

1/ *B.t.* : *Bacillus thuringiensis*

2/ 8 Billion International Units per acre in each of 1-2 applications. (*B.t.* is standarized according to its content of effective living bacteria. Its killing power is measured in comparison to the killing power of one strain that has been agreed on as the international standard.)

Commercial formulations of *Bacillus thuringiensis* are registered for aerial application against the gypsy moth. Some questions about large-scale operational use, however, remain unresolved. The unknowns include cost, ease of handling, number of applications, dilution, delivery systems, efficacy against varying population levels, and efficacy in relation to varying population trends. Until more of these questions are answered, the use of *B.t.* in cooperative suppression will be limited.

Favorable Effects. Favorable effects of using the proposed treatment materials for suppression of the gypsy moth are reflected in reports of spraying operations, which show that good control is achieved with carbaryl and trichlorfon, while *B.t.* shows promise. For effects to be considered favorable, lasting harm must not be caused to the environment. Monitoring investigations of suppression projects have been favorable, and they are continuing as a feature of control operations. Results of suppression and monitoring are described below.

Carbaryl has been found to be effective in controlling the gypsy moth, as seen from Table 7. In the four tests cited, egg mass reduction ranged from 94-100%. The foliage protection afforded by carbaryl has been documented to be excellent; Nichols (1972) stated, "Defoliations after treatments were negligible"; and Doane and Schaefer (1971) noted that Sevin 4 Oil gave excellent foliage protection. Some people have suggested that the use of carbaryl may not be effective in controlling the gypsy moth because of the vast increase in the acreage of defoliation since the start of its use. The EPA (1972) in a detailed study of the history of forest pesticide use in New York stated: "Detailed examination of hard data, however, demonstrate that such an assertion is not only oversimplifying but is, in large measure, incorrect. Much of the defoliated acreage has been defoliated because it has not been treated."

Table 7. Comparison of the effectiveness of carbaryl on the gypsy moth using different formulations and dosage rates.

Formulation	Lb/Acre	Egg Counts Pre-spray	Egg Counts Post-spray	% Egg Mass Reduction 1/	Source
Aqueous spray	1-1/4	7,000	0	100	Connola et al., 1961
Aqueous spray	1/2	2,094	6	99	Connola et al., 1966
Sevin 4 Oil	1	12,765	7	99	Doane et al., 1971
Sevin 4 Oil	1	2,663	167	94	Nichols, 1972

1/ In all publications except Nichols (1972), the authors presented pre- and post-suppression counts without stating percent reduction. For comparative purposes, percent reduction was calculated using the information from their publications.

Long-term favorable effects of suppression with carbaryl can be inferred in Pennsylvania. There in 1971 the suppression objective - foliage protection that season - was attained. For 1972 approximately one-tenth of that same acreage was proposed for re-treatment, indicating that on the other 90% of the 1971 spray acreage one treatment was enough to not only protect foliage in the year of application but also to reduce gypsy moth populations enough to provide protection a second year.

To learn effects of carbaryl applied in 1971 and to learn effects of the gypsy moth in treated and untreated stands are objectives of a five-year evaluation by the Forest Service in New Jersey, New York, and Pennsylvania. Data on the following are being taken in each situation : the number of eggs per mass and the number of masses per acre; degree of defoliation; tree condition subsequent to some regime of defoliation; tree mortality subsequent to some regime of defoliation; variation in tree increment; and variations in *Ooencyrtus* and *Calosoma* populations. In addition, data from the plot system established for this evaluation will be used in testing and modifying the predictive tables developed by Campbell and Valentine (1972).

By employing the data now being collected from the three-State area, better models and subsequently better predictive tables may be developed. Part of the mass of data taken from 1971 through 1973 is to be analyzed as an interim report for the Final Statement. To clarify the beneficial effects of treatment, more investigations than this are needed. Basic information needed includes the effects - immediate and long-term - of the gypsy moth itself on forest recreation, aesthetics, water quality, fish, birds, soil, game animals and other wildlife, aquatic invertebrates, and its own predators.

Trichlorfon also has been found to be very effective in controlling the gypsy moth (Table 8). In the tests cited, percent egg mass reductions ranged from 89-99%. The degree of foliage protection achieved by the use of trichlorfon is also excellent (Nichols, 1972; Doane and Schaefer, 1971). What might be expected from the complex interactions of wet cool weather of long duration, larval disease, and trichlorfon applied for gypsy moth suppression was learned in a 1972 investigation in New York (Tigner, 1973).

Table 8. Comparison of the effectiveness of trichlorfon on the gypsy moth.

Formulation	Lb/Acre	Egg Counts Pre-spray	Egg Counts Post-spray	% Egg Mass Reduction1/	Source
ULV	1.0	1,980	2	99	Merriam et al., 1970
80% SPA	1.0	5,350	563	89	Nichols, 1972
ULV	0.9	8,880	288	97	Gilpatrick et al., 1970
80% SPA	1.0	3,061	56	98	Grimble, 1972a
80% ASP	1.0	4,540	330	92	Doane et al., 1971

1/ In the sources cited, except Nichols (1972) and Gilpatrick et al. (1970), the authors presented pre- and post-suppression counts without stating percent reduction. For comparative purposes, percent reduction was calculated using the information from their publications.

In the first operational use of trichlorfon for gypsy moth control, Pennsylvania and New Jersey applied Dylox 1.5 Oil insecticide in 1973. Some handling, storage, and formulation problems arose which caused delays in the spray operation. The major problems included nozzle clogging and the formulation's intolerance to water. The low tolerance to water caused several loads of insecticide to be lost when they were contaminated by rain water. The nozzle clogging was attributed to several factors: the apparent purging ability of the formulation, which seemed to release foreign particles from the spray system and storage tanks; and the high-vicosity batches of formulation, caused by improper agitation at the bulk storage facility. Once these problems were solved, most of the mechanical aspects of spraying were conducted efficiently.

Slippey (1973) reported that in the Pennsylvania project, Dylox 1.5 Oil insecticide achieved the goal of foliage protection where it was applied at the proper time (less than 25% defoliation) and was not followed by rain for at least six hours after spraying. In a test of the formulation to compare the efficacy of two dosages of trichlorfon (1/2 lb and 1 lb) it was obvious that foliage protection was afforded by both application rates (Hanson, 1973)[1/]. The areas which had the 1/2 lb trichlorfon treatment received 55% defoliation, the 1 lb areas 53%, and the unsprayed areas 92% defoliation. A population collapse in the study area precluded any analysis of population reduction. Further data are expected to be gathered in 1974 on the efficacy of the 1/2 lb dosage rate to confirm the 1973 results.

Orr (1973)[2/] reported on an improved formulation of Dylox 1.5 Oil which was tested in New Jersey and Pennsylvania in October 1973. The improved formulation included lecithin, which helped the flowability and alleviated the nozzle clogging problems encountered in the 1973 suppression operation. The adjuvent also increased the tolerance of the trichlorfon oil formulation to water contamination. Lecithin is obtained from the manufacturing of soybean oil and contains oil, phosphatides, and other components that are used in foods, animal feeds, pharmaceutical, cosmetic, and other products.

1/ Personal communication with J. B. Hanson, Entomologist, U. S. Forest Service, Delaware, Ohio.

2/ Letter from P. W. Orr, U.S. Forest Service, To the Record NA-S&PF, FS, USDA, dated October 12, 1973. 1 p.

The results of aerial application of *Bacillus thuringiensis* (*B.t.*) against the gypsy moth have been variable. Lewis and Connola (1966) indicated variable results in a test with *B.t.* that resulted in a 37-97% reduction in egg masses per acre. Doane and Hitchcock (1964) also reported erratic results with *B.t.* : egg counts inside and outside treated plots showed no differences as a result of spraying with various concentrations of *B.t.* In field tests with *B.t.* in 1972 in Pennsylvania, Quimby et al. (1972) reported that two applications failed to give satisfactory control of the gypsy moth. With the two formulations of *B.t.* tested, Dipel and Thuricide, the average egg mass reduction was 19% and 70%, respectively. Tests in 1972 reported by Lewis (1973) indicated that *B.t.* generally showed good foliage protection but in most cases poor population reduction.

The results of testing *B.t.* in 1973 have been encouraging (Larson, 1973) (Table 9). Metterhouse (1973)[1/] reported that using Dipel at High Point State Park in New Jersey provided control comparable with Sevin 4 Oil. In other New Jersey tests, he reported Thuricide 16B also provided foliage protection in the treated area. The parasite data from the High Point evaluation are now under analysis, but preliminary indications are that there are more parasites - both species and number - in the *B.t.*-treated area. New York used Dipel operationally this year and received adequate foliage protection in the areas treated on Long Island (Terrell, 1973)[2/]. In tests in Connecticut using Dipel and Thuricide 16B, Kaya et al. (1973) reported there was no significant difference between the products tested. Both formulations provided foliage protection against the gypsy moth. Other tests conducted in Connecticut in 1973 also provided foliage protection against the gypsy moth (Table 9).

1/ Personal communication with W. W. Metterhouse, N. J. Dep. Agr., Trenton, N. J.

2/ Personal communication with E. G. Terrell, N. Y. Dep. Env. Cons. Bur. Forest Insect and Disease Control, Albany, N. Y.

Table 9. Results of aerial application tests of *B.t.* for gypsy moth control in Connecticut, New Jersey and Pennsylvania in 1973.1/

State and Treatment2/	Defoliation Pre	Post	Net
New Jersey (Metterhouse)			
D	21.9	27.3	5.4
C	23.7	41.7	18.0
T	34.6	48.4	13.8
C	42.8	78.9	36.1
Connecticut (Rogers)3/			
D	0-25	25-50	25
C	0-25	50-75	50
Connecticut (Anderson)			
D	-	-	21.5
T	-	-	26.5
C	-	-	47.8
Pennsylvania (Couch and Larson)			
D3/	40-60	40-60	0
C	40-60	80-100	40

1/ From Larson (1973)

2/ D = Dipel T = Thuricide 16B C = Control

3/ Representative sample of results

Several of the problems with the use of *B.t.* appear to have been resolved. Tests in 1972 and 1973 have shown that *B.t.* will provide foliage protection, but the prospect of achieving population reduction like that gained with the chemical insecticides is still in doubt. The problems yet unresolved with *B.t.* are regarded to be in the methods improvement category and not in the research aspect of the pesticide. Improvements sought include reduced number of applications, reduced dosage in terms of active ingredient and volume, and better timing of the application. Presently Dipel has EPA registration, and Thuricide 16B has a temporary use permit and expects full registration by the 1974 field season. The use of *B.t.* will still be limited by its costs, however : $4-$5 per acre for material costs, with some areas requiring two applications to achieve foliage protection. *B.t.* in 1974 may be used as an alternative for suppression in sensitive areas, such as margins of reservoirs, where chemical insecticides are not desirable. Use of *B.t.* in the regulatory program will be limited until degree of gypsy moth population reduction is comparable to that achieved with chemical insecticides.

Extensive monitoring (water, air, wildlife, fish, aquatic and terrestrial insects, and human health) was carried out in 1964 in conjunction with the New Jersey and Pennsylvania gypsy moth spraying operations. Carbaryl, applied as an aqueous suspension at one pound per acre, was judged not to cause any lasting harm to the forest environment (USDA, 1964). Another extensive monitoring effort was conducted in 1965 in Massachusetts. Carbaryl applied as in the New Jersey/Pennsylvania work of 1964 again was judged not significantly harmful (Mass. Pesticide Board, Ed., 1966). Recently the Federal EPA contracted an analysis of New York's gypsy moth control program that employs carbaryl as an aqueous suspension; the program is considered to be not detrimental to the aquatic environment, which was the subject of the study (EPA, 1972).

In 1972 a newly developed carbaryl formulation, Sevin 4 Oil, was used for gypsy moth suppression in New Jersey and Pennsylvania. In New Jersey in 1972 the Forest Service contracted with the Lake Ontario Environmental Laboratory (LOTEL) to conduct residue analyses and monitor non-target organisms; data analyses are in progress. Effects on three parasites in gypsy moth populations sprayed with Sevin 4 Oil in New Jersey is another monitoring investigation contracted by the Forest Service in 1972; Upsala College in New Jersey is responsible for conducting the study, for which interim reports relate no adverse effects of treatment on the one species studied so far (Sellmer, 1972 and 1973). In Pennsylvania the U. S. Fish and Wildlife Service monitored for effects of Sevin 4 Oil on birds and found no significant effects (Studholme, 1972b). Aquatic organisms also were monitored by that agency in streams deliberately sprayed (in a suppression operation such streams would not be treated); fish were unaffected, but insect populations were greatly reduced immediately after spraying (Pillow, 1973a). One year later those streams again contained normal populations of aquatic insects (Pillow, 1973b).

Extensive trichlorfon monitoring and residue analyses were contracted by the Forest Serice to the Applied Forestry Research Institute (AFRI) at Syracuse, New York, during 1971 and 1972. AFRI reports reveal trichlorfon causes only negligible harm to non-target organisms (AFRI, 1972; Caslick and Smith, 1973; Finger and Werner, 1973; Todaro and Brezner, 1973; Wang, 1973). Analyses are continuing. In Pennsylvania in 1972 monitoring of birds by the U. S. Fish and Wildlife Service revealed no significant effects (Studholme, 1972a). That agency monitored also for effects on aquatic organisms in streams deliberately sprayed and reported that mortality of aquatic insects was slight and fish were unaffected (Pillow, 1973a, 1973b, 1973c).

Authority. Federal control efforts before 1971 were largely regulatory, directed toward preventing spread of the insect into areas known to be free of the pest and attempting to eradicate newly discovered or established infestations. The Forest Service, under the Forest Pest Control Act of 1947, now has responsibilities for those activities that provide protection of forest resources from imminent loss, are not classified as regulatory, and are within the generally infested area.

Biological Evaluation Considerations - General. Biological evaluations are required in order to qualify for Federal cost sharing. They are conducted to determine the current levels of the gypsy moth population and to predict for 1973 the probable population levels, degree of defoliation, and consequences of that defoliation. The States in their biological evaluations use common methods, with minor variations, in assessing gypsy moth populations in the infested areas. They conduct the evaluation surveys in areas which received defoliation that year but also include areas or stands of high susceptibility to defoliation. Egg mass counts are made on one-tenth acre plots. The counts are made after leaf-drop in the fall and usually continue until January or February. The criterion for treatment is 500 egg masses per acre which, tempered by other factors, can indicate possible heavy defoliation the following season. A few acres proposed for treatment may have counts in the 300-500 range per acre. In such cases, the reason for inclusion is their proximity to very heavy gypsy moth populations; migrating or windblown larvae may heavily defoliate these areas. New Jersey Department of Environmental Protection uses a minimum of 250 egg masses per acre as their requirement for treatment.

If an area meets the minimum egg mass count for a proposed spray area, other basic information is considered before formulating the final spray decision. Some of the factors assessed include:

- Egg mass size
- Forest tree species composition
- Parasitism and predation
- Length and intensity of current outbreak
- Weather
- Water hazards
- Forest use
- Tree condition, tree size, and stocking density
- Over-wintering gypsy moth mortality
- Virus evidence or history in stand

Post-suppression surveys are conducted to evaluate the effectiveness of the suppression projects. A sample of the plots taken prior to spray are revisited to determine the extent of larval hatch in that area. A defoliation survey from the ground and/or air also gives an indication of foliage protection in sprayed areas compared with untreated surrounding areas.

One particular long-term consequence of insecticide use is the possible natural selection in the gypsy moth genetic pool that would result in population resistance to the chemical. This subject has not been studied in detail, but adaptation is considered unlikely. Factors that would discourage genetic adaptation are: 1) very few areas are sprayed in consecutive years, and 2) the genetic influence of unsprayed individuals from surrounding untreated populations (the smaller the treated area, the greater the ratio of boundary to spray area and perhaps the greater the influence of unsprayed individuals on surviving sprayed individuals). An investigation into resistance of the gypsy moth to carbaryl was made recently in New Jersey; the conclusion reached is that the insect does not exhibit evidence of resistance today (Forgash, 1973).

Economic Considerations - General. Damage to the forest resource is exhibited in many ways : loss of foliage, outright tree mortality both directly and indirectly attributed to defoliation; loss of tree vigor; loss of forest values; and direct monetary loss resulting from removal and replacement of dead trees.

Agencies responsible for gypsy moth control must have criteria for determining how to utilize their limited resources most effectively to control the insect and to satisfy public demands for action. The economic concept of "least cost plus loss" is a theoretically appropriate and generally accepted criterion, provided that the dollar value of losses for given control expenditures can be determined.

In addition to knowing the value of the forest resources threatened by gypsy moth attack, the decision maker must know the risk of their loss or injury, the cost of control measures, and the effectiveness of alternative control measures. Risk of loss estimates can be made for tree mortality using tables prepared by Campbell and Valentine (1972). Testing and refinement of those tables is in progress by the Forest Service. The monetary cost and the results that can be expected from alternative control measures are generally known for presently registered materials that can be used operationally.

Techniques for determining economic benefits and cost of gypsy moth suppression are improving, though it is apparent there is a long way to go before objective, quantitated, penetrating cost-benefit analyses can be made. These require the development of methods to determine the economic importance of gypsy moth effects on wood production, real estate, forest recreation, aesthetics, game animals and other wildlife, fish, water quality and quantity, and other features of the forest. These weaknesses are not remedied overnight, but work on some of them has started in a programmed approach initiated by the Forest Service. Methods for two types of forest use - real estate and wood production - are now available to the States.

The first method enables forest managers to estimate tree mortality due to gypsy moth defoliation and the resultant reduction in home real estate value (Payne et al., 1973). Land managers can interpret expected tree mortality in terms of percentage reduction in homesite property values through reduced tree cover. Subtle tree losses may not justify gypsy moth suppression, while greater tree losses will indicate significant changes in market value. The technique contributes to the suppression decision-making process.

The second method involves economic analysis of gypsy moth in commercial forest stands. The procedure assists in deciding for or against suppression in selected areas highly regarded for their sawtimber or pulpwood value. Essentially, merchantable tree volume losses due to gypsy moth-caused tree mortality are converted to dollar losses over the short and long runs (McCay and White, 1973).

The next phase of study is directed toward measuring and assigning values to the esthetic degradation and nuisance resulting from the gypsy moth. Confidence is growing that these complex situations will yield to economic analysis as insights improve. Some effects once considered purely environmental are becoming costs and benefits that can be described in dollar terms.

Monetary costs estimated for the suppression projects involving carbaryl and trichlorfon range from $4. to $7. per acre. For treatments involving *Bacillus thuringiensis*, where two applications may be necessary costs up to $20. per acre are estimated. Included in these cost estimates are the following:

- o Insecticide and carrier.
- o Application of insecticide.
- o Overhead, field administration, mixing.
- o Special surveys required to implement a control decision.
- o Monitoring for effects of treatment on non-target organisms.
- o Forest owner contacts for approval to spray.
- o Presuppression surveys.
- o Postsuppression surveys, for evaluating the results of the project.

Benefits include the following:

- o Reduction of tree losses.
- o Maintenance of tree and stand vigor.
- o Protection of high-value urban forests and recreation areas.
- o Reduction of nuisance from larvae.
- o Prevention of esthetic degradation.

Unique Environmental Considerations - General. Much of this Environmental Impact Statement focuses on the inter-action between suppression agents and certain components of forest ecosystems that are generally common to New Jersey, New York, Pennsylvania, and Rhode Island. In some instances, there are environmental considerations unique to portions of individual treatment units. These are discussed below by appropriate State agencies. First, though, there are discussed here the common precautions followed in the several States. Because these actions are routine in each agency, only additional actions are considered unique.

Occupants and landowners are instructed to watch the local news media for approximate project starting dates in their locale.

Numerous precautions are taken to ensure that insecticide is dispersed at the proper dosage rate and in the proper areas. Application of the material is performed only when wind velocities are less than 7 mph; the foliage is dry enough for proper adherence; the temperature is below 70°F; weather conditions indicate no likelihood of impending rainfall; and visibility is safe for proper aircraft operation.

Application operations are continually monitored by experienced personnel whose responsibilities are to check calibration of aircraft; swathing (distance between swaths); material drift; flight patterns; air speed, altitude; insecticide dispersal; aircraft safety; adherence of spray; and climatic and foliage conditions.

Suppression unit personnel monitor the treatment areas for obvious adverse effects, both during and after treatments.

Some treatment blocks contain lakes surrounded by permanent homes and summer cottages. Treatment is conducted at a specific distance from lakes, ponds, and streams, in order to minimize aquatic insect mortality. A "no spray zone" is generally established for all such bodies of water. These are safety measures to minimize any possible damaging effects that chemical insecticides may have on water quality and associated living organisms. These precautions are not necessary with *B.t.*, which can be sprayed right to the water's edge. The spray blocks will be clearly marked with Kytoons or other suitable markers. Men will be stationed at spray locations to ensure proper treatment area coverage. Radio communication or ground markers will inform pilots of a spray or no-spray situation. A safety officer is appointed to coordinate search and rescue efforts and first aid or medical attention if the need arises.

In the event of an emergency aircraft jettison of insecticides, procedures have been established for marking the areas on the ground and on maps, protecting people from contamination, and determining potential environmental effects and appropriate decontamination procedures.

Public Involvement in the Decision-making Process - General. One means of gaining public involvement is to make available to the public the Draft Environmental Impact Statement in order to gain further comments before preparation of the Final Statement (which also is made available). This passive means contrasts with the dynamic involvement of State agencies that conduct gypsy moth suppression projects. They solicit inputs from the general public, as well as from private organizations, various agencies, specialists, and a variety of officials having expertise or jurisdiction. And, solicited or not, the public makes comments on the gypsy moth.

Individual States differ in their methods of gaining public involvement, and that subject is treated below by State.

Cooperative State Treatment Proposals. The pest management efforts on State and private lands in New Jersey, New York, Pennsylvania, and Rhode Island are being conducted through cooperative agreements with the Forest Service by State agencies having responsibility for the control of gypsy moth. Where State-requested suppression projects are mutually agreed to be necessary, these agreements provide for cost-sharing on a one-half Federal and one-half State basis. A cooperative suppression project must be based on:

- Meaningful biological evaluation to determine the significance of an insect or disease outbreak, its probable course, and the results that logically can be expected if suppression is or is not undertaken.

- Economic evaluation to weigh the costs of suppression against the values saved as a result of suppression.

- Environmental evaluation of the possible adverse impacts the suppression method might have on non-target organisms and other components of the environment, the measures that must be taken to hold these impacts to a minimum, and the alternatives, including the impact of inaction.

The information below was abstracted from documents submitted by the several States in support of the gypsy moth suppression projects they proposed for 1973, modified by their preliminary proposals of projects for 1974, as follows:

New Jersey (Department of Agriculture): Cranstoun, 1972 and 1973; Fringer, 1973.

New Jersey (Department of Environmental Protection): Moorhead, 1973a and 1973b.

New York : Terrell, 1973; Preston, 1973.

Pennsylvania : Cobb, 1973a and 1973b.

Rhode Island : Murphy, 1973; D'Andrea, 1973.

New Jersey Department of Agriculture

Biological Evaluation Considerations. The procedure the New Jersey Department of Agriculture follows for biological evaluation closely parallels the general considerations mentioned in the section on "Biological Evaluation Considerations - General." Several variations in their survey scheme are worthy of mention, however. They count egg masses on one-tenth-acre plots every half mile on a grid system which encompasses the areas of known infestations. In addition to other evaluation procedures, they use one-hour frass counts and bark flap data in treated and untreated forests to measure gypsy moth larval abundance. This data, combined with defoliation estimates, is used to determine efficacy of the treatment.

The Department has documented the sequence of events leading up to a final spray or no-spray situation. Procedures are explained for their biological evaluation and further implementation of the Department's biological control program at Appendix pages 1-5. The New Jersey Department of Agriculture proposes to treat in 1974 approximtely 58,000 acres with Sevin 4 Oil and 2,000 acres with *B.t.* (See Table 6). The size of the final spray area, however, will depend upon results of evaluations still underway.

The 1974 proposed treatment would be the fourth consecutive year of cooperative suppression in New Jersey. The map immediately following is a record of all the areas treated from 1971 through 1973.

NEW JERSEY
DEPARTMENT OF AGRICULTURE
COOPERATIVE GYPSY MOTH
SUPPRESSION PROJECT
1971-73

TREATMENT AREA -

Economic Considerations. Because of the large size of the defoliation problem (see the map immediately following this page), high costs of pesticide control efforts, complexities of chemical control, and large manpower needs associated with controlling the gypsy moth, the New Jersey Department of Agriculture has formulated a chemical-biological control program directed at preventing tree mortality within forested areas of the State. This program employs both chemical and biological means (parasites and predators) to reduce severe defoliation populations of the insect. The projects provide temporary relief, by chemicals, until a more stable influence can be attained by the biological agents.

The chemical control portion of the program will be conducted only in the "high-value" areas, while the biological portion of the program will be employed in other, unsprayed areas. At the present time the State has developed a priority system by which the various "high-value" land areas are classified. They are listed by order of priority:

1. Forested communities with at least 20 homes per 100 acres, defoliated once or expecting heavy defoliation in 1974.

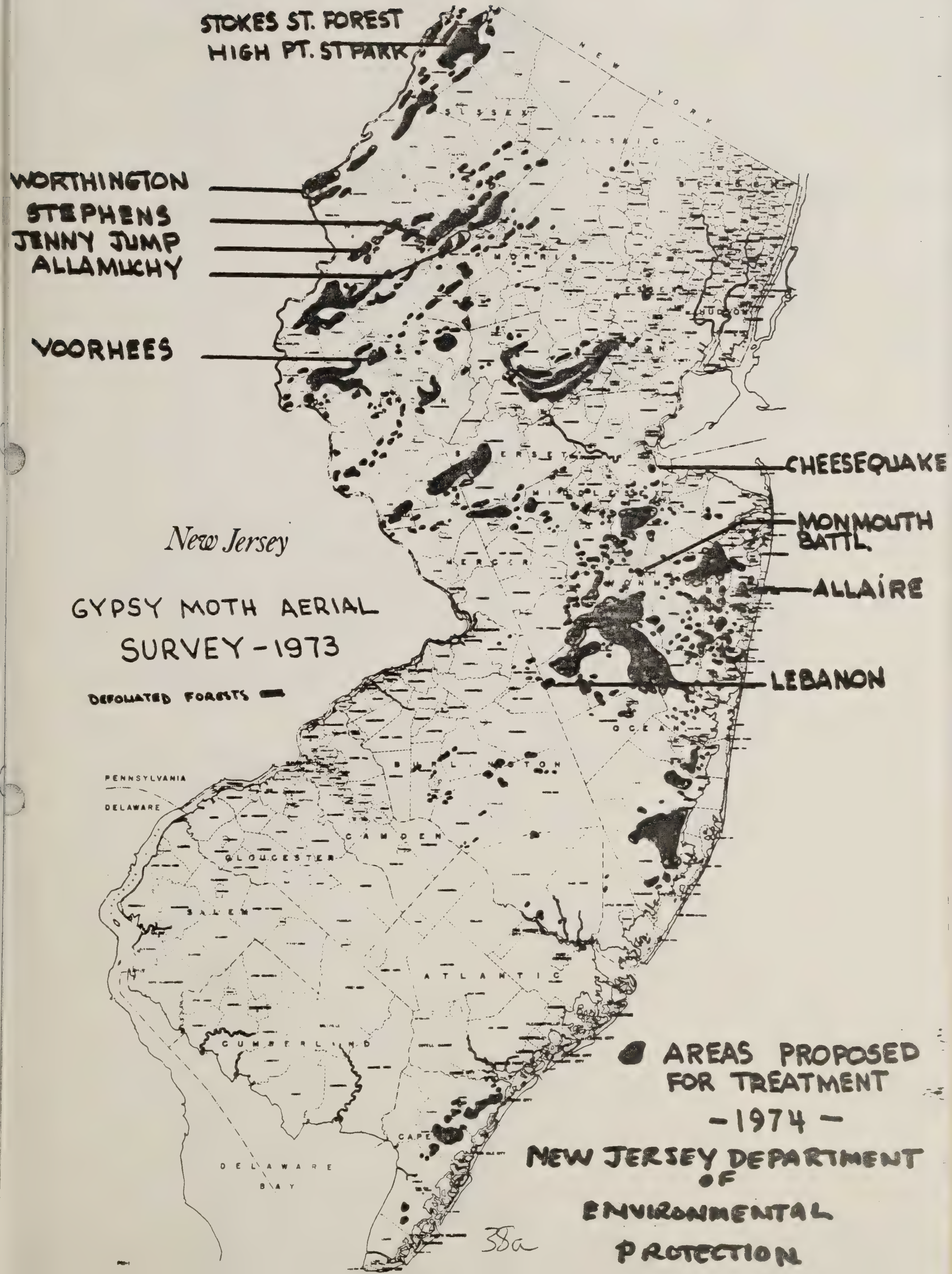
2. Municipal and county recreational areas defoliated once or expecting heavy defoliation in 1974.

3. Forested communities, with from 5-19 homes per 100 acres, defoliated once or expecting heavy defoliation in 1974.

4. Watershed areas defoliated once or expecting defoliation in 1974.

All insecticide application in the proposed project is performed by fixed-wing and/or rotary-wing aircraft. The total cost per acre, including overhead, field administration, pre- and post-treatment evaluations, mixing, monitoring and application, is estimated at $6. per acre.

Generally, an area requires only one application to bring about population control of the gypsy moth. However, in cases where treatment blocks are very small, treatment the following year might be necessary because of larval dispersion into the treated area after the insecticide has lost its effect.



STOKES ST. FOREST
HIGH PT. ST PARK
WORTHINGTON
STEPHENS
JENNY JUMP
ALLAMUCHY
VOORHEES
CHEESEQUAKE
MONMOUTH BATTL.
ALLAIRE
LEBANON
New Jersey
GYPSY MOTH AERIAL SURVEY - 1973
DEFOLIATED FORESTS
AREAS PROPOSED FOR TREATMENT - 1974 -
NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
NEW YORK
SUSSEX
PASSAIC
BERGEN
MORRIS
ESSEX
HUDSON
SOMERSET
MIDDLESEX
MERCER
MONMOUTH
OCEAN
BURLINGTON
CAMDEN
GLOUCESTER
SALEM
ATLANTIC
CUMBERLAND
CAPE
PENNSYLVANIA
DELAWARE
DELAWARE BAY

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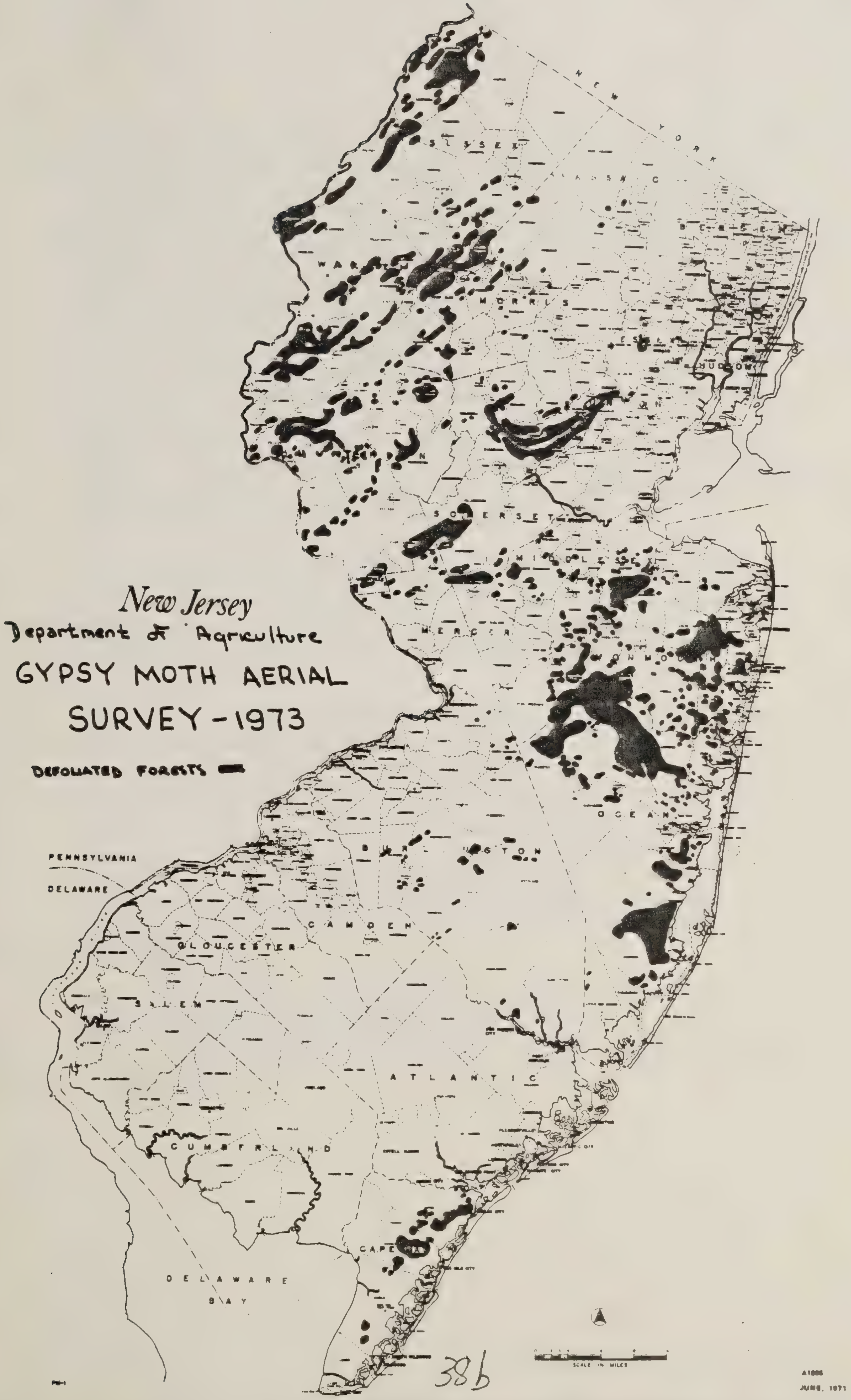


New Jersey
Department of Agriculture
GYPSY MOTH AERIAL
SURVEY - 1973
DEFOLIATED FORESTS
NEW YORK
SUSSEX
MORRIS
BERGEN
HUDSON
SOMERSET
MIDDLESEX
MERCER
OCEAN
CAMDEN
GLOUCESTER
SALEM
ATLANTIC
PENNSYLVANIA
DELAWARE
DELAWARE
BAY
SCALE IN MILES
JUNE, 1971

The major effect of the gypsy moth in New Jersey is felt in the loss of high value trees which are located in the residential and recreational areas of the state. Certainly the value of large white oaks in forested communities far exceeds the value of those same trees at the sawmill. In New Jersey, the impacts of tree loss on a forest stand are negligible if values are figured only in terms of merchantable board feet lost. If the esthetic and recreational uses are considered, these same tree losses gain much more significance. A 40% loss of oaks in a large forested tract is somewhat disturbing but this same 40% loss in a forested community would be a calamity. Tree losses in recreational and residential areas have a severe impact on the New Jersey citizen. Tree removal can range from $50. to $500. for each tree when tree mortality occurs in residential areas. This factor will offset the cost per acre for treatment. Another negative value of dead trees is the direct danger to the public from falling limbs in public recreation areas.

Esthetically, it is difficult to place a value on an acre of forested land. However, residents in forested communities are willing to pay as much as $3,000. more per acre for a completely wooded area as opposed to an open field. A proportion of that differential can be invested in spraying to protect the value of those trees.

Many of the woodlands provide recreation for people who reside in the most densely populated States in the country. The need for these green areas is becoming more important each year. During the past 10 years on two separate occasions, the New Jersey citizens have strongly supported bond issues which have been dedicated to additional public acquisition of these same green areas. The effect of gypsy moth defoliation and the resultant tree loss in these highly used areas are considered intolerable by a sizeable sector of the public. The cost-benefit ratio is greatly enhanced when these factors are considered.

Unique Environmental Considerations. Some of the treatment areas may include permanent parasite-study sites which have been in existence for several years. If this occurs, an effort will definitely be made to determine parasite levels following application.

In areas where Sevin 4 Oil is used, it will be the responsibility of the township involved to notify the bee hive owners about the spray program. The Department will help make pollen traps available with instructions on use to minimize bee mortality and obviate the need to move hives.

Public Involvement in the Decision-making Process. In New Jersey, officials of infested municipalities hold public meetings and from these meetings a decision is made to declare if the gypsy moth is a nuisance and whether treatment within the township is to be conducted. The local governing body must pass a resolution or ordinance which declares the gypsy moth a public nuisance.

The Department of Agriculture's methodology for involving the public is detailed at Appendix pages 4-5.

New Jersey Department of Environmental Protection

Biological Evaluation Considerations. The Department of Environmental Protection, Bureau of Forestry, has the responsibility for conducting evaluations on State forests and parks. They consider an area for suppression if it has a minimum of 250 egg masses per acre. The procedure they use in conducting their survey is covered in the section on "Biological Evaluation Considerations - General." They have tentatively identified 15,000 acres to be treated with Sevin 4 Oil. Further evaluation may reduce this figure.

Economic Considerations. The New Jersey Bureau of Forestry is responsible for protecting all State Forests from damage by insects and diseases, and it cooperates with a sister agency in the Department of Environmental Protection, the Bureau of Parks, to extend that protection to all State Parks.

Two treatment priority categories have been established. First priority is accorded high-use areas, such as camping areas, recreational facilities, cabins, monuments, and historical sites. Second priority is assigned to all other State forested lands threatened with heavy defoliation.

Being the densely inhabited State it is, New Jersey finds its forests and parks under great pressure from people. Several hundred thousand people annually visit the State Forests and Parks proposed for suppression. The people expect their forests to be green and usable. The gypsy moth interferes with their enjoyment by defoliating trees and being a nuisance around picnic and camping sites.

Various studies in New Jersey produced information reflecting conditions in the areas studied; Table 10 is one example (Kegg, 1972b). Nevertheless, it seems certain that mortality in the range 30-60% can be expected where repeated heavy defoliation is permitted.

Table 10. Oak losses caused by the gypsy moth on portions of the Newark Watershed, 1968-1972.

Year	Percent Oak Mortality	Average No. Dead Oaks/Acre	Total No. Dead Oaks in Affected Forests 1/
1968	6.5	6.53	116,693
1969 2/	14.3	14.40	257,112
1970 2/	38.0	38.47	686,882
1971	58.5	57.87	1,055,776
1972	63.4	64.07	1,143,911

1/ 17,855 acres
2/ Years of 70-100% defoliation of oak

Much more than dollar values are at stake in the proposed treatment areas. Considerations for areas treated in 1973 are discussed below as examples of economic concerns for areas proposed for 1974 treatment.

Allamuchy State Forest is of importance because the historic village of Waterloo is located within its boundaries. This small village was prominent during the Morris Canal era when it was a supply and repair stopover for barges and men who worked on the canal. Waterloo village is almost restored to its original state, and during the fiscal year of 1971-72 over $29,000. in visitor receipts were realized.

High Point Park contains High Point Monument, a beach and concession stand, various lodging facilities, and many picnic and campsite areas that attract people from the three-state area of New York, Pennsylvania, and New Jersey. Two additional factors which make it a high-use area are that the Appalachian Trail runs lengthwise through the park and Lake Rutherford is located near a main highway.

Monmouth Battlefield State Park is important because of its significance in the Revolution and one of the few major battles fought in New Jersey. One reason for protecting this park is to retain the site's near-natural state and keep it appealing to a high number of visitors who use it annually.

Worthington State Forest will one day be included within the Tocks Island National Recreation Area. It is estimated that its use will increase, because it offers one of the most-used scenic viewpoints in the tri-state area.

Unique Environmental Considerations. Some of the treatment areas may include permanent parasite-study sites that have been in existence for several years. If this occurs, a study will be made to determine parasite levels following application, to compare them with pre-treatment and non-treatment population levels.

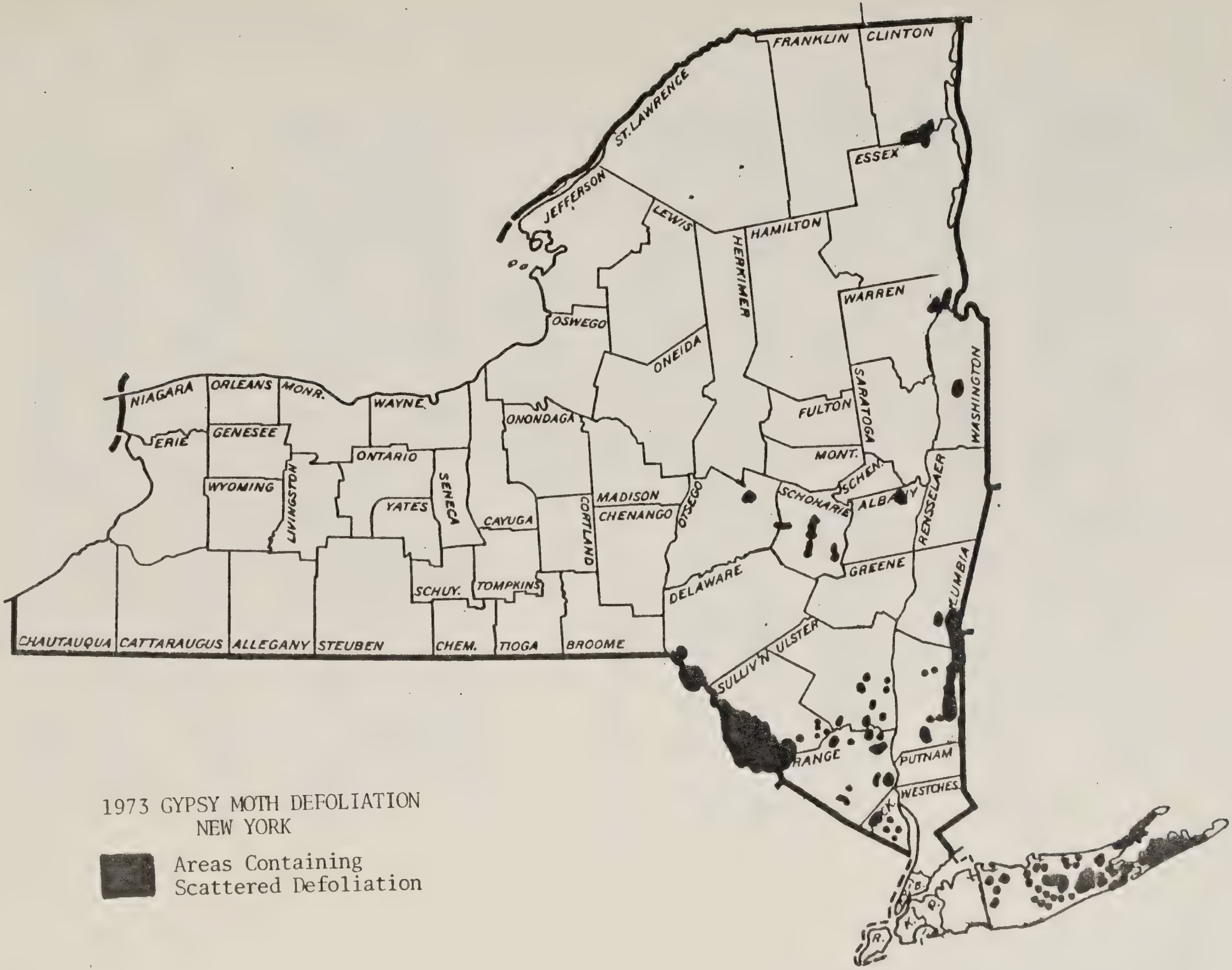
Any potential hazards within the proposed treatment areas are shown on U.S.G.S. topographic maps which will be explained to the pilots prior to spraying.

Public Involvement in the Decision-making Process. Townships adjacent to or within State lands, and local newspapers, will be informed by mail of the State-lands program. Residents who live near or within proposed spray blocks are notified of the Bureau's plans through news releases or by township officials. The State agency reasons that the public is involved also through its elected offcials, who control State-land activities by appropriations.

New York Department of Environmental Conservation

Biological Evaluation Considerations. The reader is referred to the "Biological Evaluation Considerations - General" section of the text for New York's evaluation methodology.

The areas of defoliation recorded in 1973 are outlined in the map following this page. New York personnel are planning to treat 53,700 acres with Sevin Sprayable and 2,000 acres with *B.t.*



1973 GYPSY MOTH DEFOLIATION
NEW YORK

Areas Containing Scattered Defoliation

Results of using carbaryl in 1972 were recorded. Nearly 100% protection of foliage was realized on Long Island; elsewhere it ranged from 80-95%. Carbaryl's worth is demonstrated another way : only 1-2% of the acreage proposed for suppression in 1973 was treated in 1972.

The 1974 proposed treatment would be the fourth consecutive year of cooperative suppression in New York. The maps immediately following record all the areas treated from 1971 through 1973.

The efficacy of the 1974 New York program will be measured by taking post-spray egg mass counts and defoliation estimates in the same plots used in the pre-suppression survey.

Economic Considerations. The policy of New York's Department of Environmental Conservation is to manage the gypsy moth by means of integrated control, taking into account costs and effects and effectiveness of the control measures. The State takes the initiative in carrying out gypsy moth control on State and private forest lands.

Priorities for gypsy moth treatment, in descending order, are:

1. Recreation and special use areas
2. Forested communities
3. High-value forests

1. Recreation and special use areas - Forested lands such as parks, campgrounds and others used primarily for the enjoyment of the outdoors by large numbers of people are included. Protection of this recreation and esthetic environment will yield the greatest good for the greatest number of people. Special use areas are arboreta, experimental forests, historic sites, and monuments where defoliation would seriously interfere with their primary function.

2. Forested communities - Areas containing from two to 50 homes per 50 acres of forest in the control areas are in this class. They differ from urban communities primarily in the size and forested character of the homesite.

3. High-value forests - These contain uniquely high value stands of trees which are likely to suffer either mortality or severe loss of growth from defoliation. In general, this would include high value oak species, located on good sites, the trees threatened with a third defoliation.

Such [illegible] a group [illegible]
the integrated [illegible]
are included [illegible]
serving as [illegible]
number of [illegible]
actual forests [illegible]
tion to [illegible]

[illegible]
to 50 hours [illegible]
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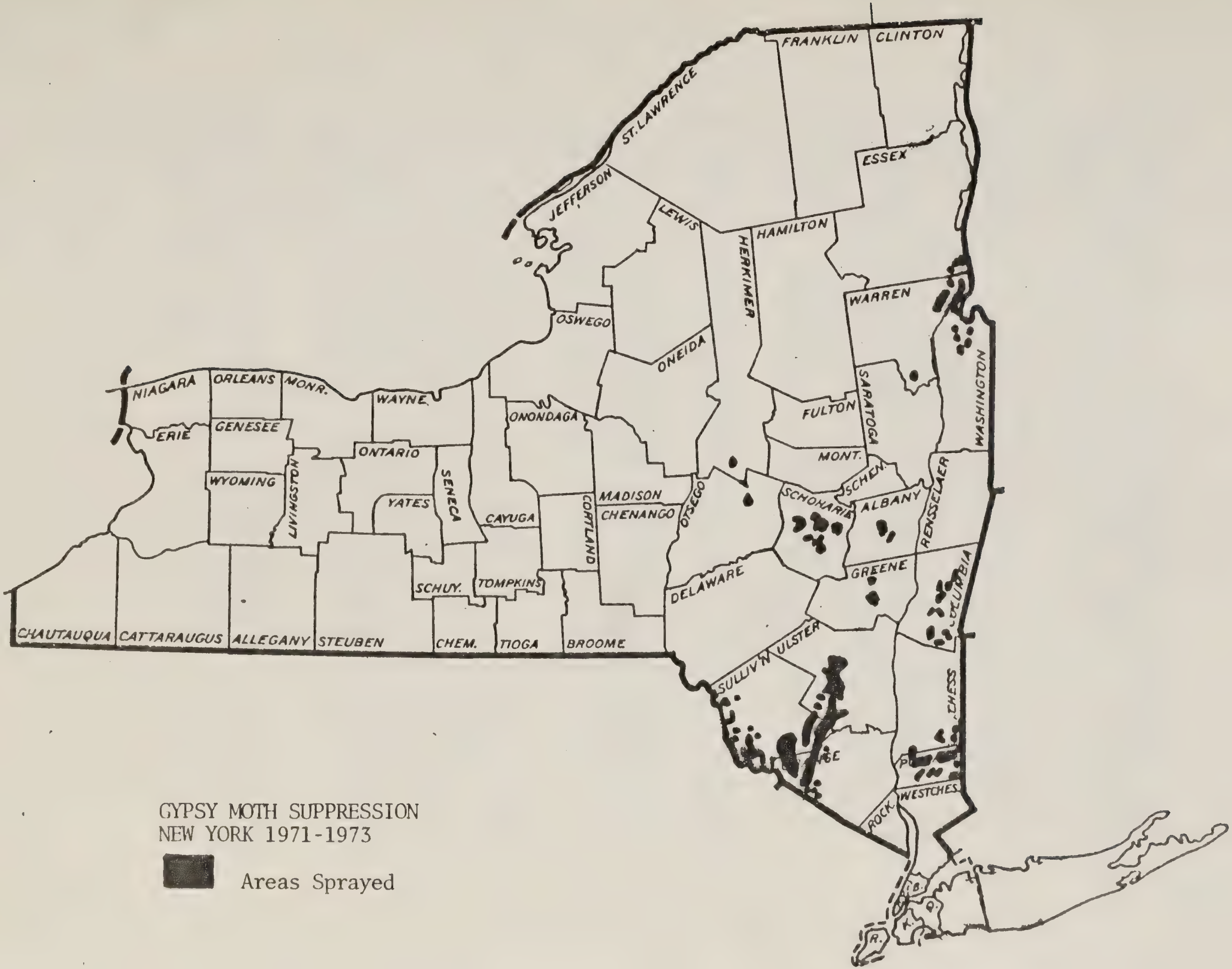


GYPSY MOTH SUPPRESSION
NEW YORK 1971-1973

Areas Sprayed

The benefits derived from spraying State camping areas fall in two general areas: tangible and intangible. There are two major tangible benefits derived from spraying: reduced replacement and removal costs of trees. Intangible values include protection against reduced public use.

Attendance varies among State Parks, but one is illustrative. Sunken Meadow State Park, on Long Island, has attendance figures respectively for the months of May, June, July, and August: 106,000, 247,000, 269,000, and 270,000. Park officials believe that severe defoliation would reduce attendance. Complaints of dropping frass over picnic areas, of denuded trees, and of general destruction of the area's esthetic values are common among people using infested parks. Furthermore, the presence of large numbers of caterpillars is looked upon as a nuisance problem, just like pests such as mosquitoes and blackflies.

An apparent benefit of treating recreation areas is to reduce the potential for spreading infestation on campers' vehicles.

Removal and replacement costs of trees on recreational areas are high. When severe defoliation occurs, tree mortality increases above the long-term average. Because dead and dying trees in such areas may pose a hazard to people, they must be removed and often replaced.

The cost associated with tree removal under contract averages about $200. per tree. This includes stump chipping to a depth of six inches below the ground level, backfilling, and sowing grass seed. Replacement costs are based largely on the quality of tree and the species. The average cost of replacing a three-inch hardwood is about $125. This includes cost of plant, planting, one year maintenance and guarantee. The replacement cost of an 8- to 10-foot Austrian pine, for example, would be about $80.

Individual tree values in forested communities are much higher than in high-value forests. The replacement cost for a 2- or 3-inch tree is $60. to $70. Cost of removal may average close to $130. per tree.

The damage resulting from 75-100% defoliation may result in tree mortality, although the actual losses depend on a number of variables. Conifers may die with only one complete stripping and hardwoods with two years of defoliation. Therefore, some mortality over and above the normal will likely occur after a single defoliation. Obviously, the hazard of losing a valuable shade or ornamental tree is high. Where severe defoliation occurs for more than one consecutive year, losses to the homeowner may amount to several hundred dollars.

High-value forest land that is 75-100% defoliated may result in a loss of $9. per acre. The losses are associated with reduction of growth and tree mortality in trees managed for wood production.

The cost of treatment, based on past figures for this type of work, ranges from $8.-$10. per acre for the actual cost of the materials and the labor to apply them. Cost for treatment with *B.t.* is estimated at $30. per acre. Considering the estimated value of the resource, it is felt that the suppression cost is justified.

Unique Environmental Considerations. To provide bee protection, it is necessary to work closely with the New York State Department of Agriculture and Markets. That agency is responsible for reimbursing bee owners who move their bees. Damage to bees as a result of spray operations is paid for by Agricultural Stabilization and Conservation Service. These agencies are informed of the program's starting date and the locations of the spray blocks relative to bee yards.

Operation of aircraft is not allowed over forested communities with more than one house per acre or over any large assembly of people. These conditions minimize the chances of an aircraft accident that could result in the injury of many people.

Department personnel interview individual landowners to document potential hazards such as farm ponds, fruit trees, bee hives, mink and poultry farms, open wells and springs, early fodder and pastures. All potential hazards and landowner concerns are marked on the spraying maps and reviewed with the pilot before spraying.

All public water supply reservoirs and coastal waters are avoided by establishing a "no spray zone" of 1,000 feet around them, and 500 feet from any related water course.

Public Involvement in the Decision-making Process. New York depends primarily on landowner contact for concurrence and permission to treat gypsy moth. The landowner interviews described above for hazards are one method of communication. As a result of such public involvement at the local level, considerable interest has been demonstrated for treating the gypsy moth in the proposed units. For example, for the 1972 suppression project in seven counties of New York, 1,866 landowners representing 43,673 acres of ownership favored gypsy moth treatment, whereas 218 landowners representing 4,474 acres were opposed to conducting treatment.

The Department of Environmental Conservation requires written permission from each landowner or his representative before any insecticide treatments are applied. This type of policy places the decision in the hands of each individual owner who is directly affected by the program. The signed permissions give the Department an insight to the involved public's view of the proposed project. For the 1972 project, the tally of landowners was 91% in favor and 9% rejecting. (Non-returns are considered rejections, too.) In early March 1973, 95-97% of the returns were estimated to favor suppression and 3-5% to reject it.

Another means of public involvement arises from the participation of Department personnel in numberless meetings with the general public and especially that part of the public directly affected.

Biological Evaluation Considerations. The reader is referred to the "Biological Evaluation Considerations - General" section of the text for Pennsylvania's evaluation methodology.

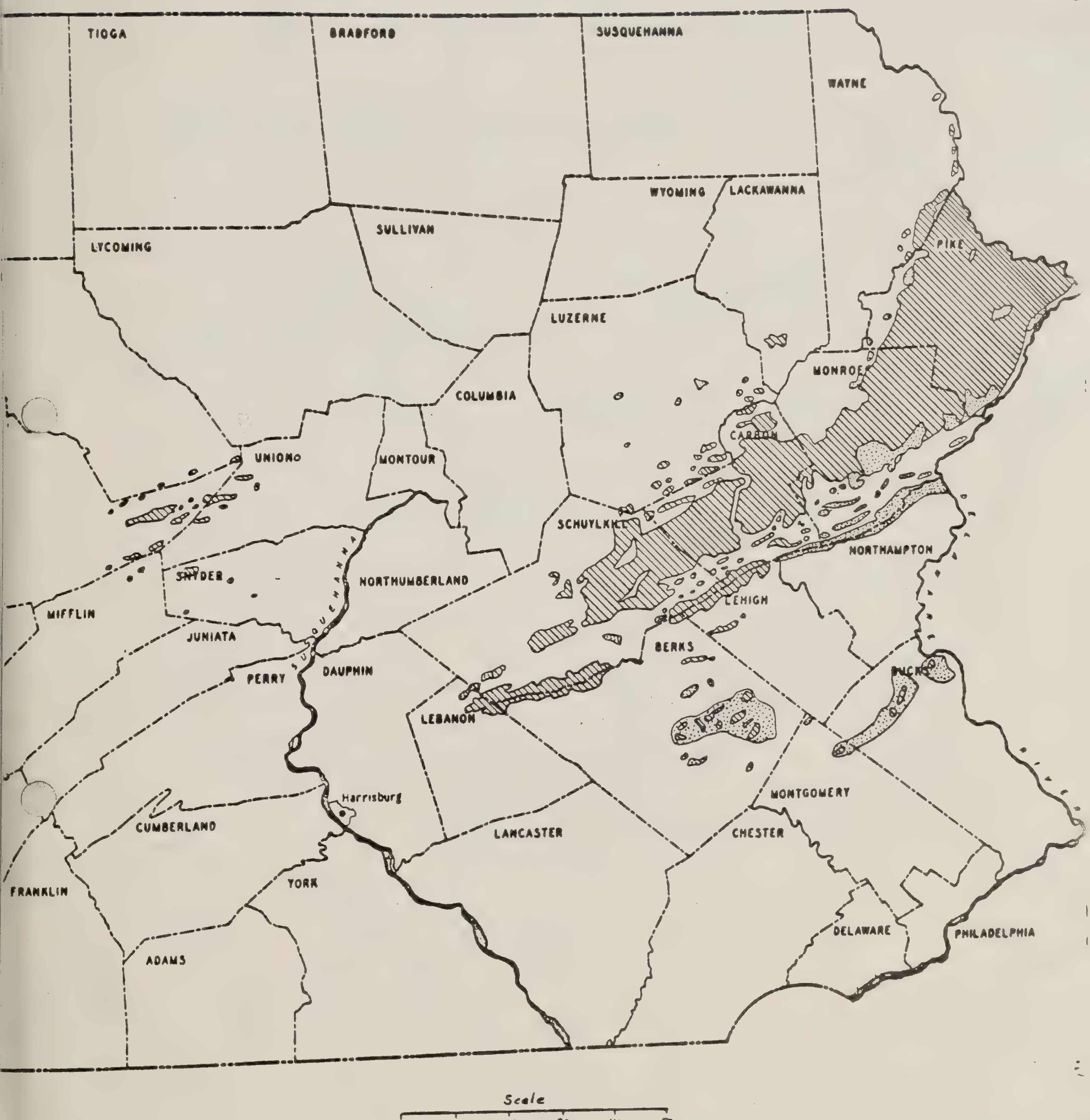
The location of the 1973 gypsy moth defoliation in Pennsylvania is shown in the defoliation map following this page.

The maximum project size proposed is 150,000 acres, which would be treated with Dylox 1.5 Oil insecticide and *B.t.* (Tables 6 and 11). Locations of the proposed treatment blocks are shown on an outline map following this page.

Table 11. Acreage proposed in Pennsylvania for gypsy moth suppression in 1974.

County	Acreage[1/]
Berks	8,000
Bucks	900
Carbon	13,000
Centre	2,000
Lackawanna	700
Lebanon	2,000
Lehigh	1,500
Luzerne	16,000
Monroe	28,000
Montgomery	1,537
Northampton	2,000
Pike	6,065
Schuylkill	11,810
Wayne	5,690
State Parks and high-value State Forest land:	
District 7 (Centre, Mifflin, Snyder, Union)	48,000
District 18 (Schuylkill)	724
District 19 (Monroe)	2,074
Totals	150,000

1/ Rough estimates only, to be refined through field evaluations.



PENNSYLVANIA GYPSY MOTH AERIAL SURVEY 1973

30 - 60% Defoliation 181,775 acres 48a

60 - 100% Defoliation 674,935 acres

[illegible]

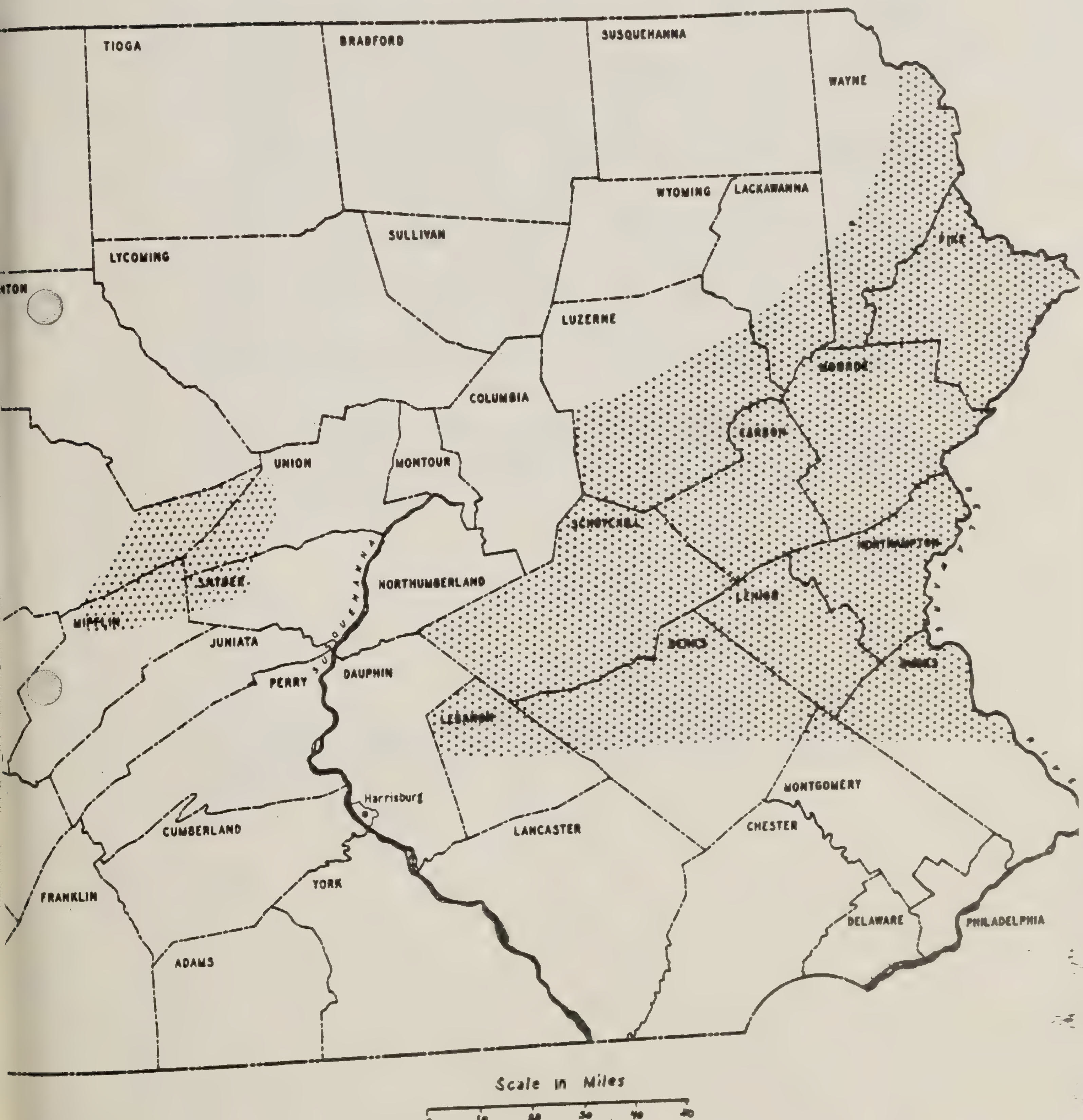
Totals

[illegible]

[illegible]

PENNSYLVANIA 1974 GYPSY MOTH PROGRAM

ACRES IN WHICH TREATMENT IS PROPOSED FOR 1974



All the proposed treatment areas will be examined to determine adherence to State guidelines.[1/] For each area examined, a field data sheet is used to record biological, economic and other information needed to decide for or against inclusion of that forested area in the proposed suppression project, based on the criteria established in the State's guidelines and those discussed at "Biological Evaluation Considerations - General". A survey of tree mortality and condition was conducted in Pike and Monroe Counties to characterize the impact of gypsy moth defoliation on trees to date in the areas of greatest public concern. Results of that survey are given in Table 12. The survey demonstrates for the Pennsylvania outbreak area what surveys in other States have found : tree mortality and decline follow heavy gypsy moth defoliation. In this case, 14% of the trees 12 inches or more in diameter (sawtimber size) and 23% of the trees 6-16 inches in diameter (pulpwood size) are dead.

The 1974 proposed treatment would be the fourth consecutive year of cooperative suppression in Pennsylvania. The map following Table 12 is a record of all the areas treated from 1971 through 1973.

1/ The State's "Guidelines for County-State-Federal Cooperative Gypsy Moth Control in the 1974 Prgram" appears at Appendix pages 6-9.

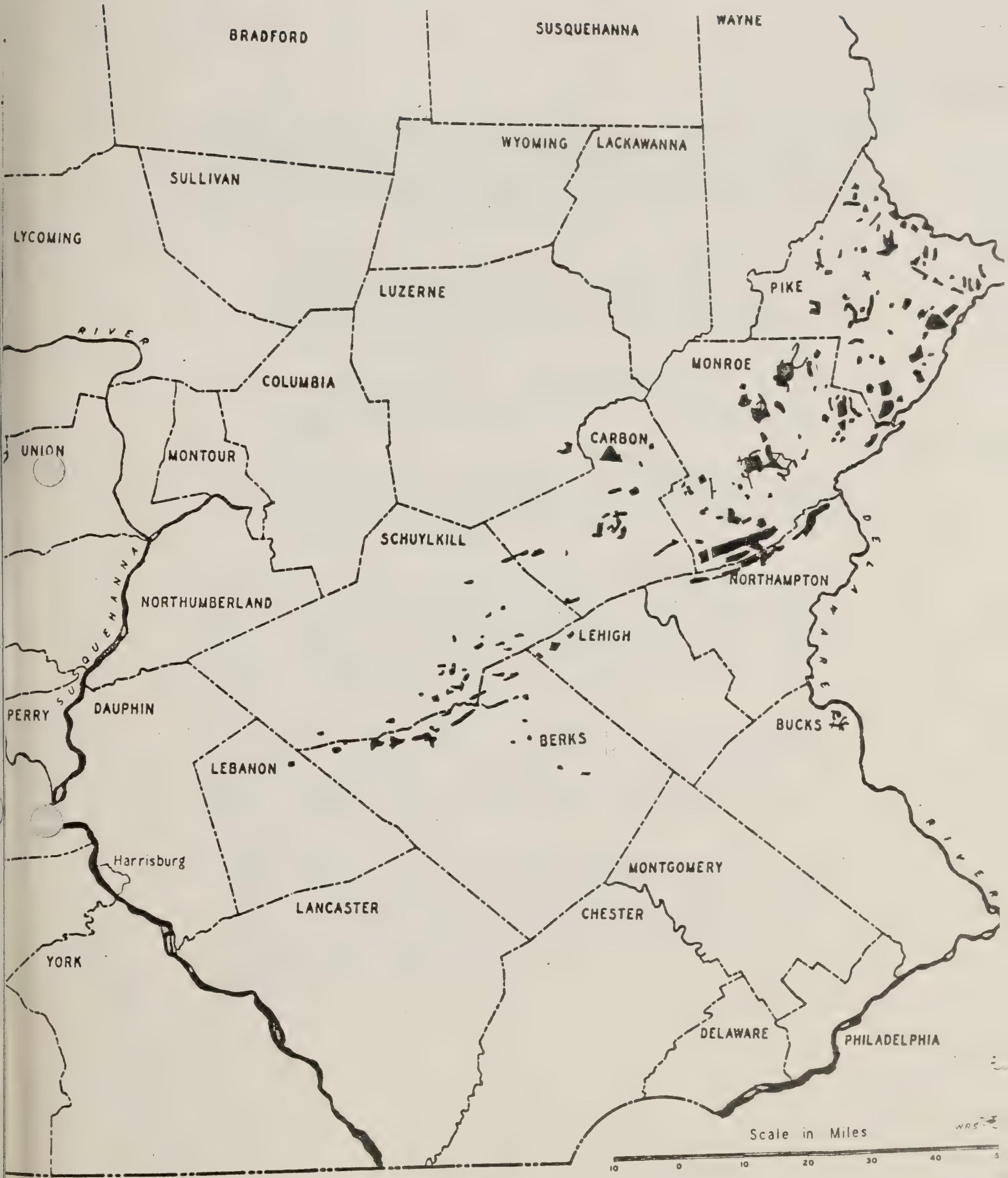
Table 12. Appraisal of tree mortality attributed to 1971 and 1972 gypsy moth defoliation in Pike and Monroe Counties, Pennsylvania - 1972.[1/]

Tree Species	Sawtimber(1,000 Bd.Ft.) Trees 12" DBH or more			Pulpwood(1,000 Cu.Ft.) Trees 6 to 12" DBH		
	Healthy	Declining	Dead	Healthy	Declining	Dead
White Oak	7,524	2,249	1,104	1,564	1,948	994
Red Oaks	931	1,961	686	417	530	221
Chestnut Oak	767	1,412	1,021	1,266	1,823	2,420
Red Maple	413	102		2,377	437	73
Black Birch	150	25		319	66	70
Hemlock						10
Sassafras				274	60	16
Pitch Pine	1,294			319	26	39
Misc.*	335	14		1,105	55	10**
	11,414 (55%)	5,763 (29%)	2,811 (14%)	7,641 (47%)	4,945 (30%)	3,853 (23%)

* Black Gum, Aspen, Beech, Hickory, White Pine
** Aspen

Summary:
1. Moderate to Heavy Mortality Area : 15,883 acres.
2. Light Mortality Area : 7,811 acres (not included in above table).
3. Oak Sawtimber : The oaks constituted 88% of the total sawtimber volume; 16% of this oak volume was dead and 32% declining and not expected to survive.
4. Oak Pulpwood : The oaks constituted 68% of the total pulpwood volume; 33% of this oak volume was dead and 38% declining and not expected to survive.
5. Total Number of trees (6" in diameter or more) dead on 15,883 acres and attributed to gypsy moth defoliation : 900,000 : average 57 per acre.

1/ Modified slightly from Quimby et al., 1972.



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PENNSYLVANIA GYPSY MOTH
CONTROL PROJECTS 1971-1973

Economic Considerations. The policy of the Department of Environmental Resources is to assign highest priority in gypsy moth suppression to those areas serving the greatest number ofpeople. Accordingly, the following areas are considered for aerial control treatments under a State-supervised contract:

1.) Forested parks, recreational areas, campgrounds, and other special-use areas such as historic and natural sites, experimental forests, endangered croplands, and watershed areas surrounding public water supply reservoirs.

2.) Forested communities and roadside strips in forested rural residential areas and containing at least two homes per 50 acres.

3.) Forested buffer zones, 200 to 500 feet wide, surrounding a community or other high-value areas if a serious hazard is anticipated from caterpillars migrating from defoliated woodlands.

One benefit of the project would be to minimize environmental harm from improperly applied insecticides. In some places where State-supervised suppression was not conducted, local people in 1971-1973 arranged for their own spraying. Personnel conducting such operations are not always trained in modern suppression techniques of forest spraying.

The following are examples of the kinds of economic impacts produced by the gypsy moth in the Poconos, where most of the spray blocks have been. Information was obtained from: (1) realtors dealing with a subdivision in Pike County, (2) a large resort (715 acres), and (3) a Scout Camp.

(1) "In the summer - the most important time for selling - lots are hard to sell when they are defoliated. Typical lot size is one-half acre and the typical number of trees is 25. Lots with trees sell for $5,000.-$12,000. each; without trees they sell for about half that. Thus, tree value is about $100. each.

(2) "Monthly income in the summer approximates $500,000. Probable loss due to the gypsy moth is hard to estimate. We judge that about 25% of the people might go elsewhere. That would take place during two months, representing a reduced income of $250,000. The $4,000-$5,000. cost of aerial spraying this acreage appears inconsequential by comparison." (The State added that the cost of tree removal and tree replacement for resorts would approximate those of forested communities.)

(3) "Campers would probably be able to put up with the defoliation. Tree loss would really hurt. We guess our tree values, on the average, are $50. apiece."

The cost of tree removal under average contract prices is about $200. per tree. The average hourly rate of a tree climber is about $4.25; usually three men are needed to make a work crew. When the owner wishes the stump to be ground up, the area backfilled and seeded, or a tree planted as a replacement, the costs may be much higher.

The demand for treatments is exemplified by mail received from Berks and Monroe Counties -- 900 letters and petitions with 2,000 signatures. Sixteen letters or petitions of opposition have been received from Berks and Monroe County landowners. Pressure from residents and local governing officials has forced county governments to propose many types of areas that either do not conform to guideline standards or are in the lowest priority.

Unique Environmental Considerations. Appropriate safety procedures that have property owner concurrence will be followed if a fish hatchery, mink farm, or other sensitive operation is in the spray blocks. Chemical treatments will not be applied within 50 feet of a lake or pond.

Consultation with other agencies either has or will be done to monitor possible adverse effects as they deem necessary. These include the Pennsylvania Department of Agriculture, Apiary Inspection Unit, the Pennsylvania Fish Commission, the Pennsylvania Game Commission, and the DER's Bureau of Environmental Protection.

Public Involvement in the Decision-making Process. Meetings will be held in all counties involved in spraying to determine both official and public sentiment. In order to participate in the cooperative program, the county or local government must follow the procedures that follow.

1.) Appoint or hire a person to handle the local responsibilities and to coordinate activities with the State.

2.) Initiate a request for control assistance by October 1st.

3.) Accompany the request by a suitable map with spray areas designated by boundaries and summary of acreage. The areas are to be designated by A, B, or C priority.

4.) Send the State copies of correspondence, newspaper accounts, public meeting results, and seriousness of the problem.

5.) If proposals are accepted, notify property owners in and bordering proposed treatment areas of the impending project by certified mail. Those objecting within 10 days of notification will have their property deleted.

6.) Assist State in its public relations endeavors in combating the gypsy moth.

7.) Execute a contract with the State in which the county or local governing body agrees to pay for 25% of the application costs.

Residents and county officials being affected by the gypsy moth have been vociferous in their demands for treatment, especially in the Pocono Mountain resort areas of Pike and Monroe Counties. The county commissioners in these two counties would like to see most of their counties treated. The demand for this project has been of such volume that the administrative and logistical costs of treatment are not limiting factors. Newsclippings and letters from county commissioners, congressmen, various groups, and individuals attest to this fact.

In the Pennsylvania program the counties, as stated above, notify the Department of Environmental Resources of areas they desire to have treated. These areas are selected by the counties based on the summer's defoliation survey, public demand as expressed at public meetings and in letters sent to county commissioners, and other areas recommended by the county government. The Department of Environmental Resources selects areas on State-owned land, i.e., State Parks and high-use areas on State Forests.

Rhode Island Department of Natural Resources

Biological Evaluation Considerations. The reader is referred to the "Biological Evaluation Considerations - General" section of the text for Rhode Island's evaluation methodology.

Rhode Island proposes 95,000 acres for treatment with Sevin 4 Oil in 1974. The locations of the proposed treatment blocks in relation to 1973 defoliation are shown on the outline map following this page.

Economic Considerations. The priorities listed below, from highest to lowest, were set by the State's Department of Natural Resources for selection of areas to be proposed for gypsy moth control.

1. State-owned and privately-owned parks and recreation areas having high use.

2. High-value timber resources, watersheds, and other intensively managed woodlands.

3. Forested and rural residential areas.

4. Wild woodlands.

In Rhode Island, with a high human population, the woodlands receive high use for residential and recreational purposes. The values individuals put on these aspects would be protected by the application of Sevin 4 Oil to reduce gypsy moth populations.

The over-all esthetic aspect of the woodlands is important to the people who live in the cities as well as to those in the forested areas. These people expect the trees to be healthy and green when they drive along town and woodland roads or to a State Forest or Park. Tourists from many states visit private and State-owned areas where they expect to find trees in full foliage. The main highway through the State is in the gypsy moth infested area in southwestern Rhode Island. The proposed suppression project would maintain the esthetic values of the woodlands that people prize so highly.

[illegible] Control [illegible]

of [illegible] per acre. [illegible]

[illegible]

[illegible]

Economic Considerations [illegible]

[illegible]

In Rhode [illegible]

residential [illegible]

value [illegible]

the recreational [illegible] property [illegible]

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forested areas. [illegible]

and green when [illegible] and woodland [illegible]

a State Forest or Park. [illegible]

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foliage. The major [illegible] through the State [illegible] and [illegible]

with forest [illegible] southwestern Rhode Island. The [illegible]

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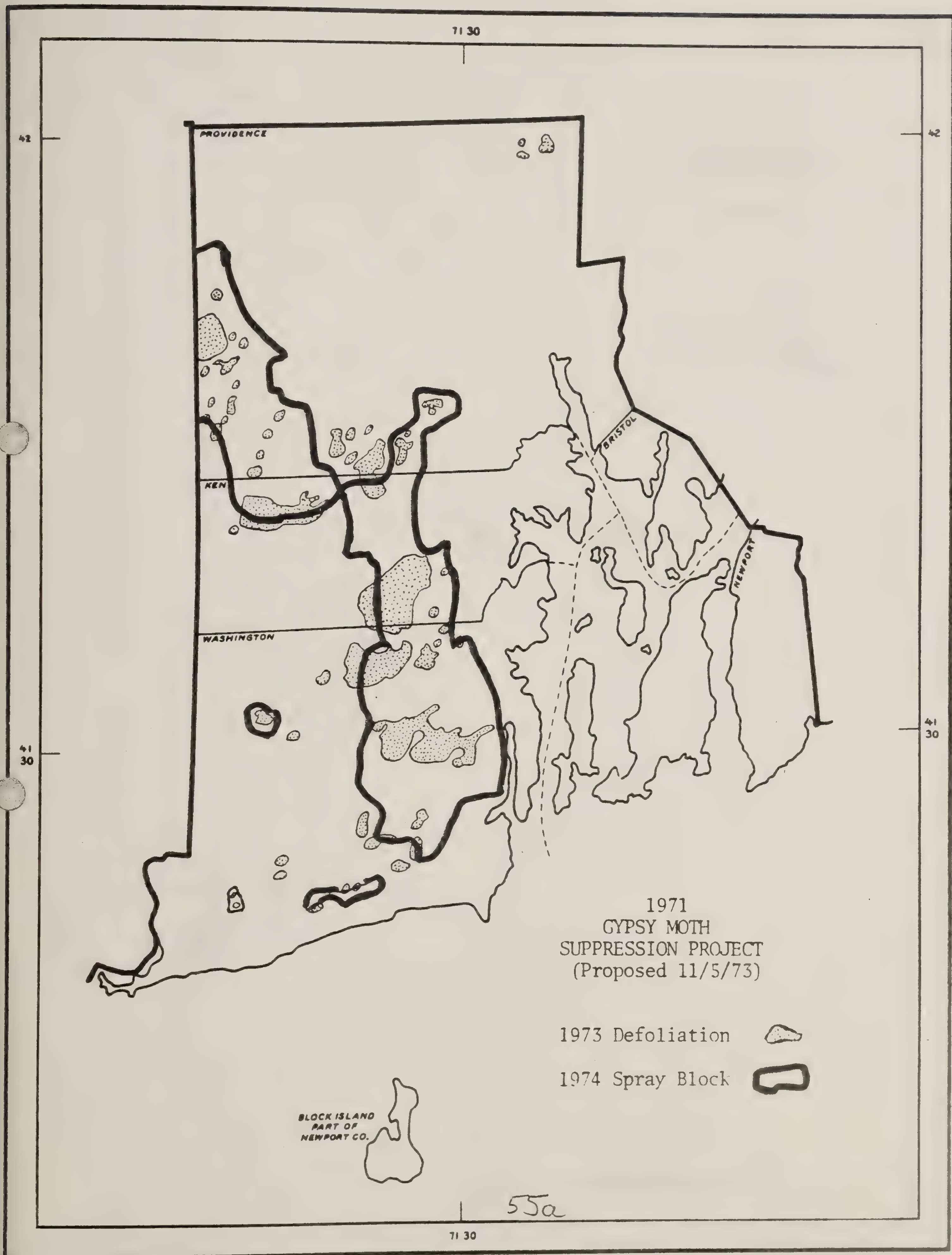
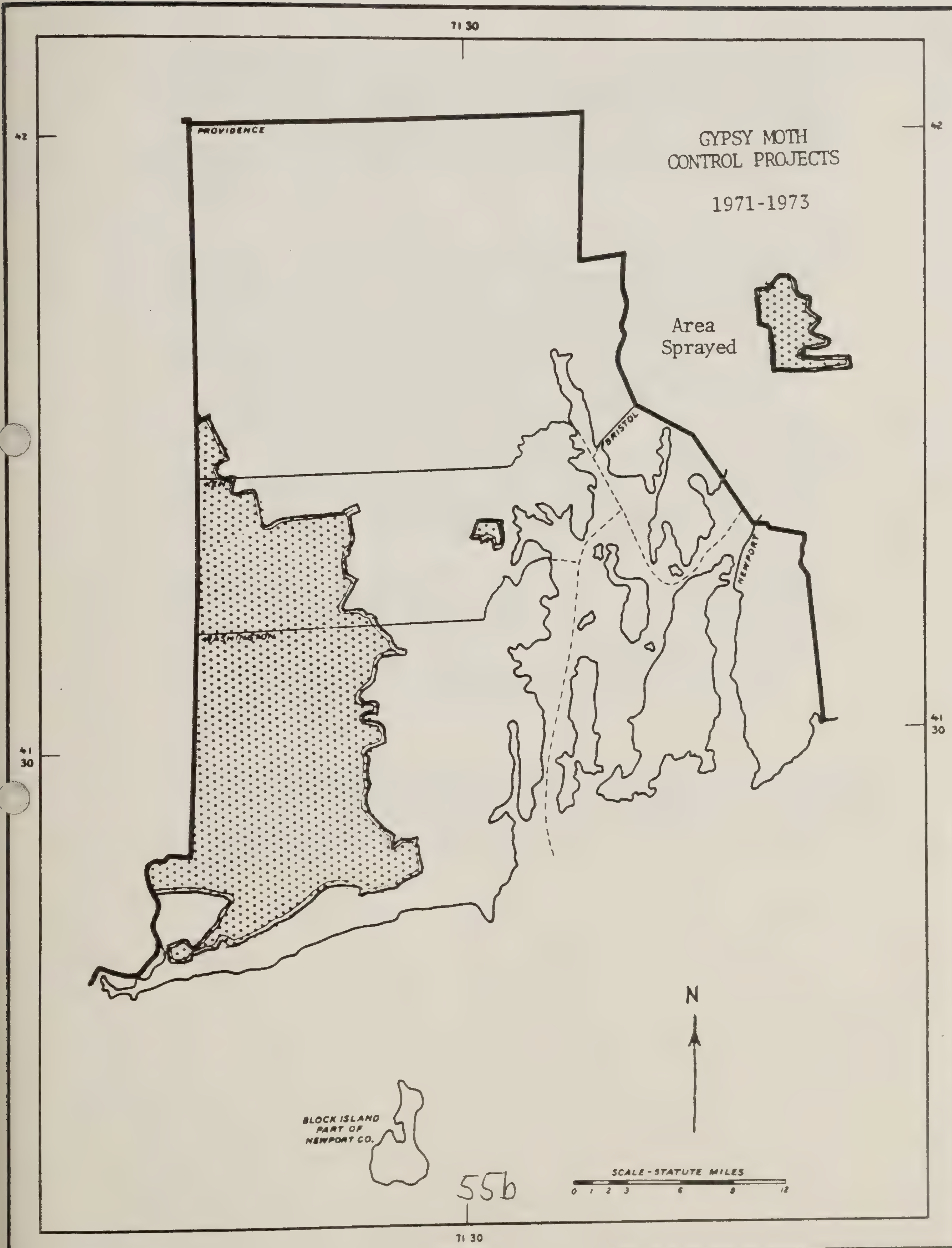
RHODE ISLAND



RHODE ISLAND



Timber and recreational values would be preserved by conducting the proposed suppression project. Timber values are a minor portion of the benefits derived from the woodlands of Rhode Island. The dense human population depends upon the woodlands chiefly for water and recreation values. If the suppression project is not carried out, losses to water values, also, would be minor.

Recreation values, however, would be severely affected if the proposed project is not conducted. Both short-term and long-term impacts are involved, with the most severe conditions being experienced in the short term on developed recreation sites. Picnic areas, youth camps, summer homes and bridle paths would be closed during the height of the defoliation. If no action is taken to prevent the gypsy moth population from running its natural course of outbreak and decline, experience in other states shows that the short-term period would likely be three years. Each summer during this short term, recreation values would decrease substantially, though to an undetermined extent. The long-term considerations would involve the removal of dead trees in high-use areas for the safety of people, an activity known to be expensive.

Consideration of the timber and watershed values and the high esthetic and recreational values in the proposed treatment areas, even though they have not been quantified, leads to the conclusion that the low cost of suppression (under three dollars per acre) and low risk of environmental harm using carbaryl as proposed are much more preferable than the economic loss and environmental degradation threatened by the gypsy moth.

<u>Unique Environmental Considerations.</u> All registered bee keepers are notified at least one week in advance of spray commencement to move the hives to non-spray areas. Bee owners are advised to keep the hives in non-spray areas for three weeks following the spray date.

Public Involvement in the Decision-making Process. Although State legislation requires the Department of Natural Resources to suppress gypsy moth outbreaks, the public has opportunities to influence decisions about proposed projects. Formal and informal public hearings and meetings held during the winter and spring in various communities provide a forum in which the public and State agency meet and communicate.

Informing the public in order to give them a chance to participate meaningfully in the decision-making process is being approached by newspaper releases and by issuing a brochure on the Rhode Island gypsy moth problem and proposed suppression project. This also has the purpose of alerting the public to the State's formal notification process, required before spraying can take place.

The process consists of publishing legal notices in the two largest newspapers in the State for three days prior to spraying. The notices describe the areas to be treated and invite people to voice their objections at that time. If their woodland has been designated for treatment, it will then be deleted from the project at the request of the owner.

PROPOSED REGULATORY ACTIVITIES (ANIMAL AND PLANT HEALTH INSPECTION SERVICE)

Favorable Effects. The gypsy moth regulatory control and containment program is a cooperative undertaking jointly planned and financed with the States involved. Interstate movement of commodities which may be infested with this insect is regulated by a Federal Quarantine. Intrastate movement of these materials is regulated under parallel State Quarantines. Quarry operators, nurserymen, dealers in timber and timber products, and industrial concerns cooperate in the control and regulatory phases of the program and they must comply with regulatory requirements. At the State and Federal levels, this cooperative program is reviewed and planned annually. Activities to be conducted are outlined in memoranda of understanding and work plans signed by State and Federal regulatory officials. The program has been approved each year by the Working Group on Pest Management of the Council on Environmental Quality.

Regulatory activities designed to minimize local spread and prevent artificial long-distance spread have been conducted continuously since 1912 following enactment of the Federal Quarantine. Artificial spread is limited by imposing restrictions on regulated articles moving from regulated (infested) areas to nonregulated (noninfested) areas. These articles are inspected and/or treated with an approved pesticide, if necessary, to insure pest-free movement. Egg masses attached to articles have been determined as the most likely means of spreading the insect to remote areas. Articles and means of conveyance not specifically mentioned in the Quarantine are subject to its regulations if an inspector determines that they present a hazard of spreading the moth outside of the designated regulated area.

Regulatory action and supporting detection surveys are kept flexible to meet changes in program developments. Adjustments are made as necessary by means of an ongoing evaluation process. Current conditions of epidemic populations in several of the infested States, resulting in increasing rates of local spread by dispersal and long-distance spread by artificial means, have increased the magnitude of the regulatory problem. Activities are designed to deal with current problems and new situations as they develop.

Authority. Authority for carrying on gypsy moth regulatory activities is contained in the Plant Quarantine Act of 1912, as amended, and the U. S. Department of Agriculture Organic Act of 1944, as amended. Federal Domestic Plant Quarantine No. 45, as revised April 5, 1973, deals specifically with the gypsy moth.

Cooperative Regulatory Program.

Survey

Surveys with sex pheromone-baited traps are conducted to detect spread along the periphery of the generally infested areas, delimit new infestations and detect new infestations in remote areas where the insect is not known to occur. In 1973 about 65,000 traps were placed in 45 States. Traps were set in a biometrically designed grid array in some cases and were also randomly distributed within a State. Special attention was given to areas where traps had caught moths in previous years. As a result of the survey, male moths were detected at a number of sites in uninfested areas. An established infestation discovered in Michigan in 1972 still persists, as indicated by the presence of egg masses in the general area of last year's find and the trapping of male moths in a number of additional counties. No moths were trapped at a small infestation found in Ohio in 1972. Egg mass surveys in the vicinity of positive trap catches will commence when foliage drop has essentially ceased. To generalize, the pattern of trap catches in recent years indicates that light infestations may exist in portions of Virginia and North Carolina.

Along the periphery of the generally infested area surveys will be continued to monitor progress of local natural spread. Trapping on a grid basis is planned in portions of some States. In addition to surveys conducted by APHIS personnel, it is anticipated that traps will be placed and monitored by other Federal agencies, State agencies, and private organizations. At sites where single or multiple moth catches were recorded the previous year, biometrically designed delimiting surveys will be utilized. Traps will also be deployed in selected areas prone to artificial introduction of the pest, such as State and Federal parks and campsites.

Insecticide Treatment

Mobile homes and recreation vehicles, including various types of mobile camper units, become hazardous when they locate within infested parks. The vehicles frequently become heavily infested with one or more life stages of the insect. Egg masses deposited on these vehicles are the major hazards.

To minimize artificial spread outside the regulated area from within the generally infested area, insecticidal treatments will be applied to hazardous parks, camping grounds, mobile home parks, rest stops, military installations, etc. Military installations are of concern because Plant Protection and Quarantine Inspectors have found and removed egg masses from military cargo and crating at such installations as West Point, New York, and the Naval Ammunitions Stores Depot in Earle, New Jersey. Federal and State inspectors who regularly monitor these hazardous sites have determined that insecticidal treatments are the most effective measures for reducing or eliminating pest risk. The end result sought in the APHIS program is more demanding than is the case with the Forest Service cooperative suppression program. That program is not planned with regulatory objectives in mind, although some regulatory benefit is gained incidental to the program's main purpose.

The aerially applied treatments completed in 1973 as part of the regulatory control program are summarized in Table 13. Insecticide formulations used were applied at the rate of one pound of technical insecticide per acre.

Table 13. Summary of 1973 gypsy moth regulatory control program treatments applied by aircraft.

State	No. Treatment Areas	Total No. Acres per State	Insecticide
New Jersey	65	6,940	Sevin 4 Oil
New York	54	11,625	Sevin 4 Oil
Pennsylvania	62	4,814*	Dylox 1.5 Oil
	181	23,379	

* Includes 1,047 acres, second application.

Additionally, Sevin Sprayable was applied by mistblower at 264 campsites and 42 mobile home parks in the New England States, New Jersey, New York, and Pennsylvania, for a total of 15,613 acres treated including 3,411 acres that received two applications.

The Michigan and Ohio infestations were aerially treated in 1973. In Michigan, Sevin 4 Oil was applied to 13,366 acres and in Ohio 335 acres were treated with Dylox 1.5 Oil. Both materials were applied at the rate of one pound of technical insecticide per acre. Sevin Sprayable was applied in both States soon after egg hatch to suppress wind dispersal of first instar larvae. About 350 acres were aerially treated in Michigan and one acre treated by mistblower in Ohio for this purpose.

The 1974 regulatory control program will generally parallel the program conducted in 1973. Aerial applications of carbaryl (Sevin 4 Oil) are planned in New York, New Jersey, and Pennsylvania. An aqueous suspension of Sevin Sprayable will be used for mistblower application in the New England States and in areas of New York, New Jersey, and Pennsylvania that are not aerially sprayed. Treatments are made in cooperation with affected States, since State authority permits entry and treatment of private lands. Table 14 outlines the proposed insecticide applications for the 1974 regulatory program. Some of the acreage listed, which will be sprayed by mistblower, will be treated more than once if necessary to maintain pest populations at low levels.

Table 14. Acreage proposed for insecticide treatment in 1974 in the regulatory control program.

State	No. Treatment Areas		Total No. Acres/State	
	Air	Ground	Air	Ground
Maine	-	11	-	70
New Hampshire	-	22	-	110
Vermont	-	10	-	85
Massachusetts	-	16	-	400
Connecticut	-	50	-	2,250
Rhode Island	-	17	-	850
New York	50	45	8,000	650
New Jersey	105	110	9,000	4,900
Pennsylvania	97	90	4,000	1,800
Totals	252	371	21,000	11,115

The 1973 survey results indicate that scattered, light infestation exists in Michigan. It also appears that light infestations may be present in portions of North Carolina and Virginia. Specific plans for coping with such situations are contingent upon further Federal-State evaluations and discussions of each affected area and the control options available. This information will be incorporated in the final Environmental Impact Statement.

It is possible that certain chemicals other than carbaryl may be tested operationally in 1974. These include the synthetic sex pheromone, disparlure; acephate (Orthene 75% soluble powder), an organic phosphate insecticide; and trichlorfon (Dylox 1.5 Oil). Information about these chemicals can be found elsewhere in this Statement.

The amounts of carbaryl and trichlorfon to be applied to the local environments will conform to label directions as approved by the Federal Environmental Protection Agency and should pose no threat to mammalian systems. Applications will be timed to minimize human exposure to direct spray droplets - persons residing in treatment areas will be notified in advance of the scheduled treatment dates in accordance with prevailing State practice.

In areas where the pest risk is not eliminated using insecticidal treatments or where control treatments are not conducted, special handling of vehicles that have visited such areas may be necessary. This would involve visual inspection of the vehicles and associated equipment. Vehicles from which visible evidence of the pest has been removed or which have been exposed to egg deposition will be treated at destinations outside the infested area at estimated time of egg hatch for the particular locality. Vehicles scheduled to leave a hazardous infested site for a destination outside the generally infested area during the larval period of the insect will be treated at origin. Sevin Sprayable in water will be applied at time of expected egg hatch to the undersurfaces of the vehicle, to other exterior surfaces if feasible, and to the ground and plant growth in the immediate vicinity. This type of treatment, applied with the vehicle owner's cooperation, may involve several hundred mobile homes and recreational vehicles annually.

Formulations of *Bacillus thuringiensis* (*B.t.*) are registered for control of the gypsy moth and have been considered for use in the APHIS regulatory program. However, although aerially applied formulations that were field tested in 1973 against the gypsy moth gave foliage protection, in some cases larval populations remained high enough to consitute a regulatory problem. Similar results were obtained when *B.t.* was applied from the ground with mistblowers.

As mentioned in the Summary Sheet of this Statement, one of the purposes of the cooperative regulatory program is to eradicate incipient infestations of the gypsy moth within the United States. There are numerous instances of successful eradication programs of this nature (Rohwer, 1971).

SPRAY MECHANICS AND TIMING

Carbaryl and trichlorfon will be applied at the registered dosage of one pound active ingredient per acre. *B.t.* will be applied at the registered dosage rate of 8 billion International Units per acre, twice if necessary. Large spray droplets, greater than 300 microns mmd (mass median diameter droplet size), can be less efficient than small droplets, less than 50 microns mmd (Himel, 1969). However, pilot control studies have proven that it is very difficult to make small droplets available to the target insect under forest conditions (Mounts et al., 1969). Studies indicate that as far as drift is concerned, the greatest potential non-target contamination hazard occurs with smaller particles. Therefore, a compromise in droplet size will be reached between those sizes that minimize drift and a size that yields a high efficiency of application. Under favorable weather conditions, standard spray aircraft using conventional boom and nozzle arrangements can make spray droplets of 150 microns mmd available to the target insect under forest conditions. Information relating to pesticides in the air is sparse except as it relates to the material's movement during application (US Dept. HEW, 1969).

The spray will be pumped from the aircraft through a system of nozzles regulated to apply the particular pesticide formulation. The system will be calibrated by trained personnel to assure that only the intended amount of active ingredient is applied on an acre. To achieve one pound of active ingredient per acre, trichlorfon is applied as Dylox 1.5 Oil insecticide at the rate of 2/3 gallon oil solution per acre. Two formulations of carbaryl will be used in the proposed projects to achieve one pound active ingredient per acre. In one, Sevin Sprayable is applied at the rate of one gallon aqueous suspension per acre, including four ounces of a Pinolene adjuvant . In the other, Sevin 4 Oil is applied at the rate of one quart oil suspension per acre. *B.t.* is applied as either Dipel or Thuricide at the rate of two gallons of aqueous suspension per acre to achieve a dosage of 8 BIU's (BIU's 8 billion International Units) of active ingredient per acre at each of two applications separated by 10-14 days.

The spray areas will be clearly marked before operations begin. Kytoons, weather balloons, flags, or other adequate means will be used to mark areas. Before spraying, pilots will visit target areas and be briefed on boundaries, safety hazards, and sensitive areas that should not be flown over. Spraying will be permitted only when winds and other meteorological conditions are such that the insecticide will be confined to the proposed spray area. Spray, when deposited, forms droplets of white material on leaves, branches, and other surfaces. These droplets can be seen upon close examination of spray deposit cards and leaves.

Prespray evaluations will be made to determine if larval emergence is consistent with predictions made from egg mass surveys. The main emphasis will be to determine if populations survived the winter and to time the beginning of aerial spray operations.

Applications of carbaryl and trichlorfon for suppression objectives will be timed to obtain maximum reduction in numbers of gypsy moth larvae. The actual application of the chemical will take place over a three-week period in May or June. Exact dates will depend on insect development. The sprays will be applied when larvae are in their early instars. This will be after all the eggs have hatched and a majority of larvae have molted from the first instar. Where preventing wind dispersal of larvae is the objective, spray application is timed for initial hatch of eggs.

In the case of *B.t.* use, two applications may be needed. The objective with the first *B.t.* application is to reach larvae when they are very young. *B.t.* is degraded by ultraviolet light, but the new formulations extend activity fairly well. The main reasons for a second application are to catch late-hatching larvae, cover further foliage expansion, and get larvae that were feeding on understory plants during the first spraying and have moved to the crowns. The interval between applications is 10-14 days.

None of the proposed insecticides is effective against the egg stage; they are applied against the larval stage. Since they have a relatively short residual life, spraying at the time hatch begins has little value in a suppression operation because the gypsy moth has a prolonged egg hatch, and insects may still be hatching after toxic effect of the pesticide has worn off. Therefore, spraying, to be effective, must be delayed until all the gypsy moth larvae have hatched and sufficient foliage is present to intercept the spray. This is not the case in those control operations directed toward preventing wind dispersal of early-instar larvae from incipient isolated infestations. In such cases, obviously, spraying at the time of egg hatch is imperative.

SUPPORTING RESEARCH AND DEVELOPMENT PROGRAM (APHIS, ARS, FS)

Research on the gypsy moth increased with the advent of the recent outbreaks. To increase it further and coordinate it more closely, the USDA agencies responsible for gypsy moth research and development submitted in November 1971 a plan that would serve as a guideline for several years. The introductory part of that plan is excerpted below.

A resurgence in research interest was generated by the recent outbreak and spread of the gypsy moth. The Department has substantially increased its expenditures for research and development related to the gypsy moth in recent years. Every available reprogramming opportunity has been taken to push toward solutions for the gypsy moth problem. For example, in fiscal year 1971 the Forest Service boosted its funding for research to $431,000. compared to $175,000. in the previous year; and the Agricultural Research Service increased the total effort of the Department by providing $1,000,000. more for research and development.

The augmented efforts have provided much basic information on dynamics of population, the natural factors that limit its numbers, and new approaches and techniques for managing it. Despite this effort, we still lack sufficient knowledge and experience either to manage the pest through the use of biological and other environmentally acceptable manipulative techniques, or to forecast accurately changes in numbers of gypsy moth, and consequently, their impacts.

Suppression and containment of the gypsy moth can be obtained only through an integrated system of management techniques. Individually and collectively elements of the integrated management system must be effective and safe, with minimal hazards to nontarget organisms and to the environment in general. Unilateral approaches have not always produced the desired result. Large-scale importations of parasites from Europe and Japan in the periods 1905-1914 and 1922-1933 did not halt its buildup and spread. Intensive use of DDT in the years following World War II undoubtedly helped keep the gypsy moth in check, but continued repetitive use of this persistent pesticide presented undesirable residues in food products. The USDA is now involved in an accelerated program of research and development that will provide the technology for this integrated management system. The goal of the program is operational use of the management technique now known to have greatest promise. A key part of the management system is a more reliable means of assessing and predicting trends and impacts of populations of the gypsy moth in various ecological situations. This goal includes the development of procedures for describing current gypsy moth populations, for forecasting changes in numbers and distribution, for assessing and predicting defoliation, tree conditions, and mortality, and for evaluating effects and consequences of alternative management strategies.

Top priority in the R&D program will be given to manipulative techniques for which technology is most advanced. These include the microbial insecticide *Bacillus thuringiensis* (*B.t.*), new non-persistent insecticides, a synthetic sex attractant, disparlure, and certain parasites and predators. Some of these may be in operational use within two years. In addition, other potentially useful manipulative techniques are being developed including a polyhedrosis virus, feeding and mating deterrents, and the release of sterile male moths. These techniques or approaches, such as silvicultural manipulation and use of genetic lethal factors, cannot be included in the present effort, but they offer possibilities for research and action in the years ahead.

Responsibilities for the R&D program are shared by ARS, APHIS, and the Forest Service. The program concentrates on screening imported parasites at Moorestown, New Jersey, and in France, and in development of the sex attractant, disparlure, at Beltsville. Developmental work on mass production of the insect will be done by APHIS at Otis Air Force Base, Massachusetts. Forest Service research at Hamden, Connecticut, covers all aspects of the program. Agencies contract extensively with extramural sources, primarily universities and state agencies, to achieve their goals.

III. RELATIONSHIP BETWEEN SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE OF LONG-TERM PRODUCTIVITY

The proposed treatment of the gypsy moth infestations using carbaryl, trichlorfon, and *Bacillus thuringiensis* at the prescribed dosages will produce no known cumulative or long-term adverse effects on the environment (CARBARYL-Union Carbide, 1970; USDA, 1964; Flores and Fairchild, 1968; Durfee, 1971) (TRICHLORFON-Chambers, 1972; Doane and Schaefer, 1971; Merriam.et al., 1970; Chemagro, 1971; Lewallen and Wilder, 1962) (*B.t.*-Briggs and Goodrich, 1959; Fisher and Rosner, 1959; Bailey, 1971). Treatment of the specified areas will prevent damage that the immediately involved public feels is worth the cost in dollars : defoliation and its associated esthetic loss; loss of shade and its cooling effects; some tree mortality due to direct and indirect effects of defoliation; devaluation of forest ownerships and direct monetary loss resulting from tree mortality and subsequent removal; and personal nuisance to inhabitants.

It is unlikely that the gypsy moth will, even in the long run, kill entire stands over a widespread area. An exceptionally severe outbreak is on the Newark, New Jersey, watershed in which 17,855 acres are involved. Cumulative oak mortality has been estimated to be 63.4% for trees over six inches in diameter. White and chestnut oaks were most severely affected with red, black, and scarlet oaks also affected. Data were collected from 30 survey stations (Kegg, 1971a and 1972b). The insect can alter the composition and density of a forest stand by selective mortality of favored host species. Although a gypsy moth population may become endemic within a forest ecosystem, the insect can return to outbreak levels under certain conditions. Those conditions are complex, but examples include the tree species present, their relative dominance levels in the forest canopy, and the pressures exerted on the gypsy moth by each insect parasite, vertebrate predator, and disease organism. Conditions vary as a result of man's alteration of the forest and through the apparently slow yet ever changing forest ecosystem.

Pesticide treatment in 1974, by preventing defoliation, subsequent loss of tree vigor, and in some cases tree mortality, may also perpetuate host tree food availability, thereby prolonging conditions conducive to high gypsy moth populations. Food supply would not become scarce as quickly as it would in areas where the insect had been left untreated. Populations could then build up from survivors of treatment or young larvae transported into the stand by air currents. That situation may, if natural control factors do not build up, require another year of treatment. This

prolongation of outbreak potential through preserving the host plants of the pest insect has apparently had no practical drawback in treatment areas of the Northeast, judged by the observation that only about 6% of the 1971 treatment acreage was re-sprayed in 1972 (and some of that due to inadequate spraying in 1971).

The example above is cited as only a possible influence on the future, but it indicates the possible desire for repeated treatment in certain situations.

That means that treatment should be limited to the most valuable tree resources, those that warrant the cost of protection for more than one year. In most areas populations have not recovered the following year; repeated treatment there, of course, is unnecessary. The small acreages resprayed in 1972 attest to this.

The 1974 pesticide treatment is not expected to have significant adverse effects on humans or populations of other mammals and birds. The treatment would not harm the production of those resources. Some non-target insect species are expected to decline, but their populations are expected to recover within a short period of time. Fish populations are expected to sustain no significant direct adverse effects of spraying. Their distribution could shift if the supply of aquatic food insects should be greatly reduced temporarily - a situation that is not expected.

Most of the total infested area will not be treated, because of less intensive human use and consequently less intensively realized esthetic value. It is expected that in those unsprayed areas the complex of diseases and other natural enemies, both native and introduced, will increase. Tree mortality also will increase there, moreso among the species preferred as food by the gypsy moth, and more severely in those forests newly invaded by the insect. That reduction in preferred food, combined with increased pressure from natural enemies and occasionally severe weather will provide natural control of the gypsy moth. The interaction of natural control forces and the insect in the eastern United States is expected to produce a pattern of outbreaks similar to that which has been characteristic of the gypsy moth in the Northeast and in Europe : years of low numbers of the insect followed by sudden outbreaks lasting three or four years. Since natural spread of the gypsy moth is continuing, the production of forest resources in the eastern United States will be affected for many years to come. The proposed action of 1974 would not substantially alter this situation, because the program is not aimed at preventing natural spread.

Improved procedures are needed if the gypsy moth is to be controlled in a way that will permit optimization of both current and long-term production of our forest resources. In the future it would seem that an integrated control program involving those alternative measures that have technologically come of age, have acceptable environmental safety, are compatible with one another, and are sufficiently effective, should be brought to bear upon gypsy moth outbreaks that exceed tolerable limits; each of these thresholds needs to be carefully defined. It is in this context that treatment with carbaryl, trichlorfon, and *B.t.* can be viewed as but one step in the continuous evolution of desirable management tools for use against the gypsy moth.

The relationship between local short-term uses and long-term productivity has been discussed in a brief prepared by the Entomological Society of Canada (Entomol. Soc. Can., 1970). The Society recommends 11 specific short-term solutions to the dilemma. Because the environmental wisdom of spraying the gypsy moth depends considerably on the size and priority of the area treated, and because the control decision itself is dependent upon the activities and influences of the public sector, the Society's final recommendation is relevant to us: It indicates a need for "informing the public of the root causes of pollution and of the price that society will have to pay to avoid it." Until man develops a control measure that provides both effective suppression of a target insect and complete environmental safety, society must elect from among the advantages and disadvantages of treating or not treating a pest population and assume the risk that goes with either decision.

IV. PROSPECTIVE TREATMENT MATERIALS

CARBARYL (SEVIN(R))

Carbaryl (1-naphthyl methylcarbamate) in its technical grade is an essentially odorless white to gray color crystalline solid. Its melting point is 142°C, its density is 1.232 g/ml at 20/20°C, and its flammability is described by a Cleveland Open Cup Flashpoint of 193°C (Union Carbide, 1968a).

The insecticide carbaryl is a broad-spectrum, relatively nonpersistent carbamate (Haynes et al., 1957) that has been used for over fifteen years to suppress various insect outbreaks (Back, 1965). Carbaryl is registered by the Environmental Protection Agency for use against many destructive insects, including the gypsy moth (Union Carbide, 1969). The bulk of carbaryl used in the United States is for application to farm crops at rates of 1/2 to 2 or more pounds of active ingredient per acre, often in repeated spray treatments (USDA, 1968). The effectiveness of carbaryl against gypsy moth is well known. One application of 1 pound per acre effectively reduces gypsy moth populations (Doane and Schaefer, 1971; Connola et al., 1966; Keller et al., 1962; Connola and Sweet, 1961; Alford, 1967).

As with any material foreign to the forest environment, carbaryl has a degree of impact on our biosphere. However, during more than fifteen years of research and practical use in spray programs against the gypsy moth and other pests, no significant adverse effects against vertebrates -including mammals, birds, reptiles, amphibians, and fish - have been reported.

Life of Carbaryl in the Environment. Carbaryl is effective against members of most insect orders (Haynes et al., 1957; Barrett, 1968). Insect species having more than one generation per year (USDA, 1968) or having one generation with staggered development within the population often require repeated applications of carbaryl, because the chemical does not generally remain effective against the target insect for more than one or two weeks. The residue of carbaryl does have effective insecticidal property for several days after spraying. In one study, most saddled prominent larvae were killed within 48 hours of an application. However, larvae continued to be killed 8 days after spraying (Grimble et al., 1970). Skoog (1971) reported carbaryl effective at 18 days after treatment of grasshoppers. Residues of carbaryl applied at one pound per acre as Sevin 4 Oil remained high (causing 63% and 77% mortality in two groups of laboratory-reared gypsy moth larvae fed leaves from trees in a suppression area) at least 60 days after treatment. At 114 days mortality from the residues was 5% and 11% (Doane and Schaefer, 1971).

Insecticide residues are degraded and diluted in the environment by a number of physical factors. For carbaryl, rain is a major factor in reducing residues (Union Carbide, 1968a). In Massachusetts rain in excess of 1.8 inches occurred 12 to 24 hours after spraying with Sevin 80S and the original 190 ppm residue of carbaryl or its degradation product on dominant scrub oak foliage was reduced to about 15 ppm three days after spraying (Wells, 1966). Chemical decomposition on plants is less important, and plants absorb only small amounts (Union Carbide, 1968a). Once carbaryl is in soil or water, however, chemical decomposition is dominant and promptly leads to less toxic degradation products. "Half-lives" are poor means of comparing persistence because they vary according to condition of application. The term is used here for only a quick, generalized comparison. The half-life of carbaryl (Sevin Sprayable, an 80% wettable powder formulation) residues is three to four days. Carbaryl, in a Sevin 4 Oil formulation, was found to have a half-life of eight to ten days on range grasses (Fairchild, 1970). On forest foliage, typical initial residues after treatment range from 30-100 ppm when carbaryl is applied for gypsy moth control. These decline to 5-20 ppm in two to three weeks (Back, 1971). Carbaryl (in that case, Sevin 4 Oil) applied at a rate of one pound active ingredient per acre on maple trees in Michigan, gave residues of 500 ppm one day after spraying, 116 ppm after eight days, 130 ppm after fifteen days and 43 ppm after thirty-five days (Fairchild, 1970). In New York, the same treatment applied to two mixed oak stands gave 192 and 55 ppm the day of spraying to 112 and 15 ppm twenty-five days after spraying (Fairchild, 1970). Forest foliage sampling may reveal excessively high or low residues, in contrast to variation on row crops. This is believed due chiefly to the varied terrain and air currents likely to be found over large forested areas in contrast to agricultural crop land. Regardless of initial deposit, though, the rate of residue loss is usually constant.

The reduction of carbaryl in a sandy loam soil can be seen in the following tabulation (Union Carbide, 1968a):

Persistence of Sevin insecticide in soil.

Carbaryl/acre (lbs)	0 days (ppm)	8 days (ppm)	17 days (ppm)	31 days (ppm)
3	1.1	0.6	0.2	0.0
9	3.4	1.9	1.1	0.3
27	10.5	5.6	2.7	0.3

In a monitoring study of a gypsy moth suppression project employing Sevin 4 Oil applied at one pound of carbaryl per acre, exposed-soil residues dropped below the detection limit (0.2 ppm) 128 days after spraying; the last samples showing residues had been taken at 64 days. Occasional forest litter samples at 128 days still had slight residues (up to 0.65 ppm); but for most, residues had dropped below the limits of detection (Willcox, 1972).

If carbaryl is applied unintentionally over open water such as small brooks or ponds, an initial deposit of 1 ppm or less in a water depth of about 4 inches may be expected to completely degrade or disappear in one or two days (Romine and Bussian, 1971; Calif. Dep. Fish and Game, 1963; Lichtenstein et al., 1966). Preliminary results look similar for water treated with Sevin 4 Oil during a gypsy moth suppression project (Willcox, 1972). Proportionately lower concentration would occur in deeper water. It may help relate this deposit to potential hazard by pointing out that many raw foods carry safe residue tolerances of 10 ppm carbaryl and that more than 1 ppm in water is required to reach an LD_{50} value for fish. In one gypsy moth study, water residues of 30 ppb dropped to 1.5 ppb on one day (USDA, 1964).

Karinen et al. (1967) concluded that carbaryl reaching shallow mud flats in marine ecosystems would probably be rapidly removed from water by adsorption on bottom mud. Chemical degradation then occurs with carbaryl and 1-naphthol likely to persist in mud for two to six weeks. Carbaryl as an 80% wettable powder was applied at ten pounds per acre to a mud flat at low tide, simulating application for oyster pest control. The initial residue (10.7 ppm) dropped rapidly the first day when the tide removed carbaryl and 1-naphthol not adsorbed on mud. Then the toxicant in the top inch of mud declined from 3.8 ppm to 0.1 ppm 42 days later.

Carbaryl decomposes or metabolizes to several substances, of which 1-naphthol and 1-naphthyl (hydroxymethyl) carbamate are the most important (Union Carbide, 1969). The relative toxicities (LD_{50} to male rats) of carbaryl and these substances are: carbaryl, 540 mg/kg; 1-naphthol, 2,590 mg/kg; and 1-naphthyl (hydroxymethyl) carbamate, more than 5,000 mg/kg. The no-ill-effect levels over a seven-day period for the same three substances are 125 to 250 mg/kg, 500 to 1,000 mg/kg and 250 to 500 mg/kg respectively.

Toxicology. The intent in this section is to present from the broad science of toxicology a description of carbaryl as it can affect one organism - man. Toxicological information on other organisms is limited here to that which throws light on human effects. What is known has been gained partly from observation of people who were exposed and partly from laboratory tests on animals that can serve as indicators. Knowing how carbaryl acts on man permits one to understand more readily what may be expected from a release of carbaryl into the environment in the manner described in this Environmental Impact Statement. Those expected effects are discussed under ENVIRONMENTAL IMPACTS.

Carbaryl belongs to a group of insecticides known as carbamates. These affect animals (including insects) by inhibiting cholinesterase activity (they attack the central nervous system). In the case of carbaryl, the inhibition is reversible and animals not killed recover quickly. Of the carbamate insecticides, carbaryl is one of the least toxic (Weiden and Moorefield, 1964). No accumulation occurs in animal tissues, and the insecticide is biodegradable. Transfer from prey to predator does not occur; therefore, no biomagnification of residues takes place within the food chain (Union Carbide, 1970).

Direct exposure of people provides the most reliable information on effects of carbaryl on man, but man is no experimental animal. Nonetheless, three situations provide opportunities for data on man himself: occupational exposure, people volunteering for some tests, and accidental poisoning.

Occupational exposure is well documented in a New Jersey program (Altman, 1971). There the Community Study on Pesticides has summarized the effects of carbaryl on employees working with the compound. Tests of gypsy moth workers were made each day of each spraying operation for five successive years. Comparison of cholinesterase activity of the gypsy moth group and the control group showed no significant difference, and no ill effects were reported. At a carbaryl-formulating plant, 35 workers were monitored for effects of exposure to carbaryl; results were "within normal limits, with occasional abnormalities" (Altman, 1971).

Volunteers ingested carbaryl in daily doses of 0.06 and 0.13 mg/kg for six weeks. They "suffered no subjective or objective changes clearly attributable to carbaryl other than a slight, reversible decrease in the ability of the tubule of the kidney to reabsorb amino acids in the group on the higher dose" (Wills et al., 1968).

Accidental poisonings reported to Union Carbide have been rare - 18 from 1960 through 1971 (Dernehl, 1972) - despite the marketing of millions of pounds of carbaryl annually in the United States. Although those poisonings resulted from massive overexposures caused by extreme carelessness, the effects usually produced were only nausea, sometimes vomiting, abdominal cramps and some sweating; even those symptoms lasted only a short time, as would be expected from the rapid reversibility of carbaryl-induced cholinesterase inhibition in warm-blooded animals (Dernehl, 1971). Among the 18 reported cases of poisoning, 7 involved children, and they were less than five years old. In some of these cases, symptoms included convulsions. Follow-up examinations of these children has revealed no evidence of permanent harm (Dernehl, 1971).

Knowledge of carbaryl toxicology can be extended without using man itself. Such indirect information comes from the use of laboratory animals whose responses are indicative of responses in people if the toxicological experiments are designed and conducted in a manner similar to the ways people might contact carbaryl and if the animals metabolize carbaryl similarly to man. Many tests and animal species have been used.

Standard tests for toxic effects are first described below; they include LD_{50}, inhalation, carcinogenicity, and teratogenicity. Some further tests shed additional light on carbaryl; those touched on below involve brain effects, central nervous system effects, interaction with diet, and interaction with drugs. Common to all these indirect tests of effects on man is the certainty that man himself was not the test animal. Despite that, knowledge applicable to man can be gained from them when they have been properly designed and are objectively interpreted by qualified people.

LD_{50} ratings for insecticides and other compounds are determined in standard ways to permit comparison among them for toxicity. A standard test animal is the laboratory rat; two LD_{50} determinations are standard : acute dermal and acute oral. The acute dermal LD_{50} for carbaryl is greater than 4,000 mg/kg (endrin is 15 mg/kg, DDT 2,510 mg/kg, and malathion 4,444 mg/kg). The acute oral LD_{50} for carbaryl is 500-800 mg/kg (endrin 5-17.8 mg/kg, DDT 113-118 mg/kg, and malathion 1,000-1,375 mg/kg) (Bailey and Swift, 1968). The probable lethal oral dose for man is one ounce to one pound (Bailey and Swift, 1968). The LD_{50}'s place carbaryl in Class 4 ("slightly toxic") on a scale of toxicity ratings that range from Class 1 ("extremely toxic") to Class 6 ("relatively harmless") (Bailey and Swift, 1968). Insecticides of the toxicity of carbaryl are required to carry the word "Caution" on the label (Union Carbide, 1970).

Inhalation toxicity of carbaryl is low. Guinea pigs tolerated a four-hour exposure to an easily visible dust cloud of Sevin 50W at 390 mg/m^3 (Union Carbide, 1970). Chronic exposure presents no special hazard, because carbaryl is rapidly metabolized and excreted (Carpenter et al., 1961).

Carcinogenicity (the ability of a material to cause cancer) was considered for carbaryl, along with 82 other pesticides, by an Advisory Panel and published in "Report of the Secretary's Commission on Pesticides and their Relationship to Environmental Health" (Mrak Committee Report) (US Dep. HEW, 1969). The Panel included carbaryl with just two other pesticides as "Compounds judged 'not positive' for tumor induction on the basis of tests conducted adequately in two or more species". That conclusion for carbaryl was reached on the basis of these extensive tests: repeated subcutaneous injection studies in mice; daily inclusion of carbaryl in the diets of rats and of mice for two years and for 18 months, respectively; dermal application of carbaryl to mice for their lifetime; and continuous exposure of rats during and after reproduction for three generations. While a Russian paper (Andrianova and Alekseev, 1970) reported some positive results in rats, their experimental design was not applicable to potential hazard for man. They used repeated oral intubation instead of inclusion in the diet, and their results were compared to a control group that was inapplicable. Their sample of carbaryl was reported to contain some impurities not present in carbaryl produced in the United States.

Animal experiments must be carefully designed before their results are applicable to man. Rigorous guidelines have recently been proposed (Weil, 1970), and an impressive proportion (86-100%) of the toxicologists and other scientists who commented is in virtual agreement with each of them (Weil, 1972). Under extreme, non-applicable conditions, many materials have resulted in tumors for animals. These include hard-boiled eggs as the diet for mice (Szepsenwol, 1957 and 1964) and repeated subcutaneous injection of glucose in rats. The evidence, from applicable experiments, is strong that carbaryl is not carcinogenic.

Teratogenicity (the ability of a material to produce birth defects) of the chemicals in our environment is understandably an emotion-charged subject. Research findings concerning teratogenic effects have been placed in perspective by a recent report of the President's Science Advisory Committee (US, 1971).

"Teratogenesis induced by chemicals is a fetal response at a particularly sensitive period in embryonic development to lower doses of the chemical than are acutely toxic to the mother. Birth defects can be produced in the embryo through many mechanisms of injury when the agents are administered during critical periods of organogenesis. It is generally held that by careful choice of dosage, which may be close to the acutely toxic dose for the mother, most chemicals might be shown to be teratogenic in animals. For a variety of reasons, it is not possible to translate directly the results of experiments in animals to man. There are differences in sensitivity which arise from differences in metabolism. Comparative metabolic studies in man and animals, therefore, are important in interpreting toxicity for man.

The important consideration is not only the demonstration of teratogenicity, which may occur with many chemicals at selected dosages, but the estimation of the likelihood of teratogenic effects with the amounts likely to be ingested incident to recommended use."

Carbaryl poses no threat of teratogenicity at the dosages and by the methods proposed for gypsy moth control. Results are described below for tests with rats, mice, guinea pigs, hamsters, rabbits, dogs, and Rhesus monkeys.

Rats were fed carbaryl at 2,000, 5,000, and 10,000 ppm in their diets for three generations; effects were seen at the highest dose; fertility was impaired, no litters were produced for the second mating of the second generation, survival of progeny decreased, and litter size declined (Collins et al., 1971). Cotton rats (*Sigmodon hispidus*) produced fewer offspring and had more absorbed and stillborn embryos after they were treated by oral intubation with 1.1 mg of technical grade carbaryl in polyethylene glycol on each of two days; the first treatment was in the tenth day of apparent pregnancy (Barrett, 1968).

Pregnant mice were fed carbaryl at 66.7 and 200 ppm in their diets. The laboratory performing this study considered the number of cases among treated animals not significantly different from the number among the untreated (US Dep. Hew, 1969).

Guinea pigs administered carbaryl at 300 mg/kg during pregnancy produced offspring that included some with birth defects. This is not surprising, since the dosage level was so high that it killed 38 percent of the parents (Robens, 1969).

Hamsters at sublethal carbaryl dosages of 125 and 250 mg/kg showed no teratogenic effects (Robens, 1969).

Rabbits given carbaryl at 50-200 mg/kg showed no effects (Robens, 1969).

Dogs (pregnant beagles) were fed carbaryl daily at rates of 50, 25, 12.5, 6.25, and 3.125 mg/kg of body weight. Teratogenic effects were found in all but the lowest dosage (Smalley et al., 1968).

Rhesus monkeys fed carbaryl at 20 mg/kg daily before and after they were pregnant showed no interference by the chemical with conception or delivery. However, there was an indication that carbaryl may induce abortion in these monkeys (Coulston, 1969).

The literature dealing with tests of carbaryl for its reproductive and teratogenic effects was recently reviewed (Weil et al., 1972). Guidelines have been proposed for the proper design of studies to predict safety of materials for man. In the four studies or parts of studies that were conducted in accordance with the guidelines, no teratogenicity or reproductive effects occurred (Weil, 1970 and 1972).

In summary, greatly exaggerated dosages of carbaryl have affected embryonic development and survival and postnatal growth and survival in some species. These dosages, however, are much higher than people could possibly encounter during the proposed gypsy moth control operations.

Brain effects were considered in Rhesus monkeys exposed to low dosages of carbaryl for 18 months. They were evaluated periodically by encephalograms during anesthesia-induced sleep. No specific alternation in EEG patterns characterized carbaryl. Bilateral synchrony between right and left hemispheres was increased by carbaryl as well as by three other insecticides tested (Santolucito and Morrison, 1971).

Central nervous system effects in miniature pigs were produced by intravenous injection of carbaryl at 25 mg/kg; the dose produced paraplegic syndrome. The same syndrome was produced by chronic administration of 125 mg/kg daily (Michel et al., 1971). Symptoms of central nervous system disorders were observed in swine given feed containing carbaryl at dosages of from 150 to 300 mg/kg body weight daily for 8 to 12 weeks (the single oral lethal dose is between 1.5 and 2 g/kg in swine) (Smalley, 1970).

Interaction with diet has been considered for carbaryl in two investigations with rats. In one, iodine deficiency was studied; in the other, the subject was reduced protein intake. A study of iodine deficiency in the diet of rats demonstrated that carbaryl can be an exacerbating force in the development of endemic goiter (Shtenberg and Khovaeva, 1970). Further information on this work performed in the Soviet Union is needed before interpretation of the results would be sound. Reduced protein intake enhanced the oral toxicity of carbaryl in albino rats; LD_{50} values were reduced as the amount of casein in their diets was reduced (Boyd and Krijnen, 1969).

Interaction with drugs has been studied in the case of monoamine oxidase inhibitors (MAOI), antidepressants that show promise against Parkinsonism. The study indicates the possibility that MAOI could slow the rate of carbaryl metabolism and excretion, thus extending the toxicant's life in the body (Culver et al., 1970).

Conclusions that can be drawn from exposure data on man relative to toxicity of carbaryl are that man can cope with unusual amounts he might swallow, large doses on his skin, and an atmosphere contaminated with carbaryl - conditions much more extreme than the brief and minor exposure he might experience in the proposed gypsy moth treatment areas.

The following is a summary of extrapolations from tests on laboratory animals to possible effects in man. These tests extend that knowledge gained from direct exposure of man to carbaryl. Evidence from appropriately designed animal experiments and from human experience is that carbaryl will not be carcinogenic or teratogenic to man. Neither will it result in effects during reproduction. Although vastly exaggerated or abnormal experimental conditions can produce effects with carbaryl, the same is true for many products. Aspirin and vitamin A, for example, can produce birth defects under exaggerated conditions. Biological effects are dose-related (Weil, 1972), and effects produced from only extremely large doses or abnormal conditions are unrelated to potential hazard to man. Therefore, applicators and other people who might be exposed during gypsy moth spraying will most probably not be harmed in any way.

Again extrapolating from lab experiments with test animals, it is possible that carbaryl effects could be enhanced in man if he were under stress from specific drugs or malnutrition.

TRICHLORFON (DYLOX$^{(R)}$)

Trichlorfon is the common name of dimethyl (2,2,2-trichloro-1-hydroxyethyl) phosphonate. The insecticide has various trade names, but Dylox and Dipterex are the most common. In its technical state trichlorfon is a white crystalline solid with a specific gravity of 1.73 at 20/4°C. and a flash point of 183°F. (Chemagro, 1968).

The insecticide trichlorfon is a broad-spectrum organophosphate which is registered for use on a wide variety of field crops, vegetables, seed crops, ornamental trees, and flowers. It is also used to control lice and horn flies on cattle and as a wormer in horses. Registration is being sought for parasite control on fish.

One of the two trichlorfon formulations currently registered for aerial application against the gypsy moth is Dylox ULV. Tests by Gilpatrick and Terrill (1967) showed that it gave very good control of the gypsy moth. They stated: "An egg mass reduction of 98% was observed in the treated area, whereas an increase in egg masses of 44% occurred in the check area in 1967." Merriam et al. (1970) found that trichlorfon was as effective as carbaryl for controlling the early instars of the gypsy moth. Prespray egg mass counts were 1,980 per acre while the same area after treatment with trichlorfon had only two egg masses per acre. Doane and Schaefer (1971) also reported excellent foliage protection from use of trichlorfon. Unfortunately, Dylox ULV has a disadvantage precluding its use where most gypsy moth suppression is planned : it pits certain automotive paint finishes. Acrylic paints are vulnerable.

The other formulation, recently developed, is Dylox 1.5 Oil insecticide, tested against the gypsy moth in 1971 and 1972 under the name Dylox 80% SPA in oil. This formulation does not harm auto paint. In Pennsylvania in 1972 gypsy moth population reduction (measured as pre-suppression egg masses to post-suppression egg masses) of 89% was achieved. At the same time, defoliation in the trichlorfon treatments averaged 19%, while it averaged 88% in the no-treatment plots (Nichols, 1972). Also, in New York in 1971 Dylox 80% SPA in oil was very effective (Grimble, 1972a). In a 40,000 acre suppression project using Dylox 1.5 Oil in Pennsylvania foliage protection was achieved when proper spray conditions existed (Slippey, 1973). Hanson (1973)[1/] reported 53-55% mean defoliation in areas treated with Dylox 1.5 Oil whereas unsprayed areas received 92% defoliation. (See page 26 for further information on efficacy.)

1/ Personal communication with J. B. Hanson, Entomologist, USDA Forest Service, Delaware, Ohio.

As with all foreign materials released in the environment, trichlorfon has a degree of impact on organisms. Its attributes are that it is relatively non-persistent; relatively non-toxic to bees and to their relatives, the wasps (which include parasites of the gypsy moth); safer to aquatic organisms than carbaryl; and relatively non-toxic to *Calosoma* beetles. It is quite toxic to flies, a group that includes some parasites of the gypsy moth. Trichlorfon, on the basis of research information and practical use, has shown no significant adverse effects against vertebrates, birds, reptiles, amphibians, and fish (Lewallen and Wilder, 1962; Pearce, 1970; Chemagro, 1971b; Chambers, 1972; Caslick and Smith, 1973; Finger and Werner, 1973; Todaro and Brezner, 1973). Bird activity is affected through the reduction of insects available for food (Doane and Shaefer, 1971; Caslick and Cutright, 1973).

<u>Life of Trichlorfon in the Environment.</u> Trichlorfon has an effective life against gypsy moth of several days. A contract study for the Forest Service showed that the mortality during the first 24-hour period was over 70%, and then decreased over a 5-day period to about 30-40% (Grimble, 1972a). Nearly ideal conditions prevailed for maximum residue persistence and maximum larval mortality during this period. Doane and Schaefer (1971) found that gypsy moth larvae fed leaves collected 12 days after treatment experienced 2.5% mortality. The plots had received four heavy rains before the leaves were collected. In the same study, there was 80.5% mortality of larvae exposed similarly to leaves treated with carbaryl. Willcox (1971) showed that after 26 days there was still 0.33-3.3 ppm trichlorfon on the leaves, 0.42-1.1 ppm on the twigs and about 1.5 ppm on forest litter. Residues were still detected in leaves, twigs, and forest litter at 106 days post-spray, although the level of residues did decline rapidly over the first seven days following spraying (Devine and Willcox, 1972). Small residues (0.12-0.81 ppm) of trichlorfon were found in eight of nine samples of forest litter collected 343 days after the spray was applied. The biological significance of those residues was judged to be of negligible importance (Grimble, 1972b). Weiss et al. (1973) reported that Dylox 80% SPA residue levels dropped sharply within a few days after spray and by 60 days had reached the following percentages of their initial levels: 15% in leaves, 5% in litter, 10% in unexposed soil, and less than 1% in exposed soil.

In New York (Judd et al., 1972), trichlorfon was found in small amounts in water samples collected immediately after spraying, but the concentration of the chemical dropped below a detectable level four days after spraying. Fish samples contained no residues, but minute amounts were detected briefly after spraying in samples of rooted aquatic plants and in frogs (Devine and Willcox, 1972). Pimentel (1971), however, stated the persistence at detectable levels of trichlorfon in water at 20°C was 526 days. This was

the result of laboratory work by Muhlmann and Schrader (1957) using buffer solutions in the pH range 1 to 5; the 526 days is calculated and theoretical. The work does not reflect the fact of degradation of trichlorfon under field conditions. Under field conditions in 1972 residues of trichlorfon applied as Dylox 80% SPA dropped below 1% of initial levels within 15 days (Weiss et al., 1973).

The half-life of trichlorfon in water at 30°C was 4.7, 0.6, and 0.1 days at pH levels of 5, 7, and 9 respectively; water in this test was protected from light. In an outdoor pond (pH 7.0) and temperature 29°C average, and with exposure to sunlight and wind, trichlorfon showed a half-life of only 0.3 days (Chemagro, 1971b).

Trichlorfon (4 lbs/1 gal LS) was sprayed on sloping plots of three soil types: sandy loam, silt loam, and high organic silt loam (Chemagro, 1971b). Application was made at 20 lbs active ingredient per acre followed by simulated rainfall applied once weekly for five weeks. After a 5-week period, total residues in the runoff water from silt loam amounted to 2.86% of the total applied. For the soils, losses were 0.65% (sandy loam) and 0.35% (high organic silt loam). In New York studies (Judd et al., 1972) Dylox was not detected in any of the forest soil or lake mud samples. Willcox (1971) reported that after 14 days no trichlorfon was detected in the soil.

<u>Toxicology</u>. Trichlorfon, like other organophosphates, manifests its toxicity by depression of cholinesterase. The cholinesterase action, as with carbaryl, is reversible, so animals not killed recover rapidly from the toxic symptoms. The acute toxicity data for trichlorfon indicate it is much less toxic than most other organophosphorus pesticides.

Trichlorfon has been given orally as a therapeutic drug to 289 patients at excessive doses - over 24 mg/kg/day administered up to six days - without any serious accidents. In no case did the side effects last very long or cause irreversible damage (Wegner, 1970). Trichlorfon has been used as a therapeutic agent to control internal parasites of man for nine years without any detrimental effects on man (Abdalla et al., 1965; Beheyt et al., 1961; Davis and Bailey, 1969; Wegner, 1970).

The LD_{50} for rats was 450 mg/kg when fed trichlorfon orally (Metcalf et al., 1962). Male and female beagle dogs were given diets containing 0 ppm, 50 ppm, 250 ppm, 500 ppm, and 1,000 ppm of trichlorfon for a period of one year without exhibiting marked changes in growth rate, food consumption, or cholinergic symptoms. When amounts greater than 250 ppm were fed, there was a marked inhibition of the cholinesterase activity of the serum and red blood cells, though without symptoms (Doull et al., 1962).

Chemagro (1971a) reported the inhalation LC_{50}, expressed in ug/l, for various Dylox formulations: ULV - 4 lbs/gal (rats-female) 3,600 and (mice-female) 2,400; with 80% SP (rats-female) greater than 20,000. They also expressed the dermal LD_{50} for 80% SP (rats-female) as greater than 2,000 mg/kg.

Lorke (1971) in a study of pregnant rats found that dosage rates up to 100 mg/kg of body weight cause neither embryotoxic or teratogenic effects. Dosage rates of 100 mg/kg caused diarrhea in four out of twenty animals. Dosages of up to 30 mg/kg were harmless. He also reported that treating male mice with either 50 or 100 mg of trichlorfon per kg of body weight does not promote dominant lethal response in germinal cells of the mouse. Pregnant ewes were treated with an oral dose of Neguvon (Dipterex) at the rate of 2.5 g/100 lbs of live weight at about one month and again at two weeks before lambing commenced (Southcott, 1961). No abortions were observed and apparently the ewes lambed normally. Garner (1972)1/ stated that FDA officials have reviewed Chemagro's toxicology studies in detail and determined that trichlorfon should not be considered a carcinogenic compound. One study involved a four-year feeding test using dogs in which there were no changes in morphology considered to have been drug-induced.

1/ Letter dated August 8, 1972, from C. F. Garner, Coordinator, Federal and State Projects, Chemagro Corporation.

BACILLUS THURINGIENSIS (*B.t.*)

This pesticide is commonly referred to as *B.t.*, the initials of the active ingredient *Bacillus thuringiensis*, an aerobic spore-forming, crystal-producing member of the bacterial genus *Bacillus*. There is no chemical name for this pesticide since it is based on a living bacterium.

B.t. is available in three formulations: wettable powder, aqueous concentrate, and dust. Water is the generally accepted diluent for wettable powder and aqueous concentrate formulations. Dust formulations are not diluted. There are presently three companies which manufacture and have registrations for ground application of *B.t.* against the gypsy moth in the United States. The formulations are Biotrol XK, Dipel, and Thuricide-HPC. For aerial application Dipel, a wettable powder, is registered, and registration of Thuricide 16B is expected.

Most of the early laboratory and field data were obtained on preparations of *B.t.* based on strains of the bacterium classified as serotype I. A brief resume of field results from this earlier work against the gypsy moth is given below. Today, however, *B.t.* preparations produced in the United States are based on a strain belonging to a different serotype.

Reported field trials in the period 1961-66 indicated improved results in attempts to control the gypsy moth with *B.t.* These improved results were due primarily to improvements in the commercially available formulations. Evaluations were based primarily on population reduction (egg mass reduction or direct larval mortality) or on foliage protection. The consensus of these reports indicated variable results, particularly from aerial treatment. Some foliage protection was noted, but populations of the insect were not reduced to the levels desired (Lewis et al., 1962; Lewis and Connola, 1966; Doane and Hitchcock, 1964).

In addition to the gypsy moth, virtually all major forest insect lepidopterous (Lepidoptera : the moths and butterflies) pests proved to be susceptible to the killing effect of *B.t.* However, many of the gypsy moth field tests following favorable laboratory tests failed or gave unacceptable control effects. The reasons for these field failures are usually ascribed to:

1. Lack of persistence in the field.
2. Poor application techniques.
3. Effects of environmental factors such as ultraviolet light, rain, foliage effects.
4. Poor formulations.
5. Instability of product.
6. Inadequate coverage, particularly from the air.
7. Insufficient field effects of the *B.t.* strain used.

Testing and field observations point to a very high level of safety to non-target organisms when *B.t.* is applied to control agricultural and forest pests. It is this safety that has encouraged investigators to continue working with the material to achieve control of the gypsy moth (Bailey, 1971; Heimpel, 1971).

In 1970, *B.t.* for the control of insects took a new turn. A new isolate, HD-1, identified as a variety *Kurstaki* serotype III, was propagated and exhibited a much greater degree of effectiveness than earlier preparations. Laboratory tests showed that the new isolate was 10-100 times more effective than commercial preparations based on the serotype I Berliner strain. This new isolate was put into commercial production and now forms the basis for the three commercially available United States products. The first laboratory and field efficacy trials with these new products were conducted against agricultural crop pests, such as the cabbage looper. Crop damage evaluations and population reductions compared favorably with chemical insecticide controls. Laboratory evaluations of these new products gave encouraging data, so that several field tests were conducted in 1971 against selected forest insect pests, including the gypsy moth, spruce budworm, elm spanworm, saddled prominent, and hemlock looper. The 1971 tests showed clearly that the new *B.t.* preparation under experimental conditions can achieve at least one of the objectives of control : foliage protection.

Data from aerial tests of Dipel and Thuricide in 1972 gave indications of good foliage protection but relatively unsatisfactory population reductions of the gypsy moth (Quimby et al., 1972, and Lewis, 1973). Data from both operational and experimental use of *B.t.* in 1973 show that foliage protection in all instances was satisfactory (Larson, 1973). The *B.t.* applications were used in six separate projects which ranged over four states. Data regarding population reductions obtained in these projects are not yet available. The cost of *B.t.* is still prohibitive for large projects, but increased use is anticipated for special high-use areas and for control projects adjacent to public water supplies.

Life of Bacillus thuringiensis in the Environment. There is a scarcity of data on the longevity of *B.t.* in the environment. The studies that have been made indicate that the spore will persist in soil for several weeks depending upon the soil type, soil flora, and extrinsic factors such as pH, moisture, and radiation. The conclusion reached from a study of soils treated with *B.t.* when the material was applied for vegetable pest control was that spores can remain viable for long periods (over three months), and the organism can germinate, compete vegetatively and sporulate successfully under favorable soil conditions (Saleh, 1969). No data is available on the survival of the crystal. However, since the crystal is proteinaceous, degradation by the enzymatic action of soil flora can be presumed.

Survival of *B.t.* on leaves is minimal when no additives are included in sprays (IMC, 1968). Biological activity is usually restricted to 3-5 days. However, new formulations designed to protect *B.t.* from ravages of environmental forces have shown considerable biological activity after 21 days of field exposure and negligible biological activity after one month.

In view of the body of safety data regarding the effects of *B.t.* on human, domestic animals, fish, birds, and beneficial insects indicating no ill effects suffered by test animals, no monitoring for adverse effects of *B.t.* applied over forests has been reported.

Inasmuch as *B.t.* is exempted from tolerance, no residue analysis on food or feed has been performed when *B.t.* has been used for forest insect control (Heimpel, 1971).

Toxicology of Bacillus thuringiensis. Eighteen humans each ingested one gram of Thuricide daily for five days. Complete physical and laboratory examinations were given prior to the experiment, at the end of the five-day ingestion period, and 4-5 weeks later. Physical examinations included detailed history and records of height, weight, temperature, blood pressure, respiratory rate, and pulse rate immediately after exercise and 30 and 60 seconds thereafter. Evaluations were made of genitourinary, gastrointestinal, cardiorespiratory, and nervous systems. Lab tests included routine urinalysis with qualitative and quantitative urobilinogen determinations (when indicated), complete blood count, sedimentation rate, blood urea nitrogen, glucose, bilirubin and thymel turbidity tests. All subjects remained well during the course of the experiment. All laboratory findings were negative (Fisher and Rosner, 1959).

Fed to groups of 10 mice (16-25 gms.) at the rate of 10 gms/kilogram (1.5×10^7 I.U./kg) Dipel caused no mortality. LD_{50} was beyond 10 gms/kg (IBT, 1970a). Dipel was fed to three female mongrel dogs. Dosage was 400 mg/kg (6×10^6 I.U./kg). The animals were symptom free during the 48-hour observation period (IBT, 1970a).

Dermal effects of *B.t.* were tested by application to shaved flanks and bellies of albino rabbits. Dosages ranged from 20 percent suspensions to 50 mg/animal. After application, half of the treated skin was abraded while the other half was left intact. Readings were made at 24, 48, and 72 hours in one test and up to three weeks in another. Other than local, mild erythema (abnormal redness of the skin), no ill effects were noted in any test animal (Fisher and Rosner, 1959; Corlett, 1961). In another study, dermal application to albino rabbits was made to test allergenicity response. Ten sensitizing doses were applied every other day for three weeks. Readings were made 24 hours after each application of *B.t.* Two weeks after the tenth application, a challenge dose was applied. Only slight erythema and edema were noted. No allergenic response was elicited (Fisher and Rosner, 1959). Allergenicity was also tested with guinea pigs following the procedure of Draize. No allergenic response was noted (Fisher and Rosner, 1959).

Inhalation studies of *B.t.* were conducted on mice, rats, guinea pigs, and human volunteers. In one test with mice, the animals were exposed to 10 gms of *B.t.* powder for 15 minutes. Dosages were applied four times over a period of six days. No ill effects were noted and gross pathology was negative (Fisher and Rosner, 1959). In tests with rats and guinea pigs, exposure to a 10 percent *B.t.* preparation for 10 minutes produced no fatalities for the one-week observation time. Dyspnea (discomfort) was noted, but recovery was rapid. The animals showed normal weight gain (Fisher and Rosner, 1959). Five human volunteers inhaled 100 mg *B.t.* powder daily for five days. Complete physical examinations prior to the test, immediately after the test, and 4-5 weeks later showed no abnormal conditions in the test subjects (Fisher and Rosner, 1959).

Ocular irritation with *B.t.* was tested in albino rabbits. A dosage of 0.1 cc of a 20 percent suspension was instilled in each eye. One eye was immediately rinsed with isotonic saline. Six animals were tested. The eyes were examined immediately, after 3 hours and 24 hours, and every 24 hours until they appeared normal. Slight redness of the eyelids was noted at 3 hours and 24 hours. Eye irritation disappeared in 48 hours (Fisher and Rosner, 1959).

B.t. administered by mouth as the spore-crystal complex to rats daily for three months at rates of 25, 100, and 400 mg/kg produced no main function disorders or organ damage. Similar results were obtained in dogs fed 6, 25, and 100 mg/kg for three months (Fisher and Rosner, 1959; Corlett, 1961).

V. ENVIRONMENTAL IMPACTS

ADVERSE EFFECTS OF CARBARYL, INCLUDING ANY THAT ARE UNAVOIDABLE

Careful timing of spray application will be required to avoid the need for two applications. The gypsy moth has a prolonged emergence from the egg, and there is a risk in spraying before the entire population has hatched from the egg stage. By withholding application until larval emergence is completed and foliage has begun to develop, yet treating before defoliation is excessive, a single application can be applied and a maximum degree of spray effectiveness can be obtained. Thereby also, environmental contamination will be minimized. (This does not apply, of course, in those occasional situations, of limited acreage, where spraying must be timed earlier to prevent wind dispersal of larvae.)

No instance is known where rain action or run-off has contaminated a non-target area with carbaryl, and caution will be exercised to prevent spray from reaching such areas. Even with a well-executed aerial spray project, however, spray deposition in certain non-target areas cannot be avoided. Small openings in the forest canopy, inconspicuous streams, small bodies of water such as ponds, pools, puddles, and bogs will receive some spray deposit. Therefore, buffer strips will be maintained around domestic water supplies and other reservoirs, lakes, and rivers. Despite precautions taken to prevent direct spraying of bodies of water, some unavoidable drift of finer spray droplets may reach larger lakes and streams. The likelihood of this increases if the wind and air currents are not correctly considered. Because the amount of material settling into such non-target areas should be small, its effect on the environment should be slight, if any (Boschetti, 1966). The probability of any possible non-target area contamination decreases rapidly with time (Fahey et al., 1968; Borash et al., 1961; Felley, 1970). In similar projects conducted in 1971 and 1972, observable adverse effects did not occur (Sellmer, 1972; Studholme, 1972b; Willcox, 1972).

Terrestrial Organisms.

Man and his Food

Under normal safety precautions, personnel exposed to the spray would sustain no adverse effects. Available information suggests that careful regulation of spray delivery and maximum possible avoidance of spray application on crops or livestock will minimize food contamination. Furthermore, in light of extensive registered use of carbaryl on agricultural crops, the small amounts of carbaryl that might reach food plants or livestock would not be detrimental.

Impact could begin at the airport where the insecticide is being handled. Similar operations in New York and New Jersey have produced no effects on personnel at the airport. Standard cholinesterase tests run during spray operations conducted in New Jersey showed no effects on those people involved in handling carbaryl. These tests were conducted each day of each operation for five successive years. No respiratory ailments have arisen in forest spraying operations.

Although there is little danger of human poisoning by carbaryl (Bailey and Swift, 1968), safety precautions will be taken to assure that no worker will be unnecessarily exposed to the insecticide. People in an area being sprayed with one pound carbaryl per acre at the time of spraying are expected to receive no more than 0.3 mg/kg of body weight (Union Carbide, 1970). Rabbits showed no adverse effects when treated with a skin application of 5,000 mg/kg, a considerably greater amount than will be encountered during gypsy moth suppression. The estimated time of spraying will be announced prior to treatment.

The tolerance level established by the Environmental Protection Agency for blueberries and strawberries is 10 ppm. Application of one to two pounds of carbaryl per acre can be made a day before picking without exceeding this tolerance (Union Carbide, 1968a). One to two pounds active ingredient carbaryl per acre is the usual dose for commercial crops of these berries. Carbaryl residues decrease rapidly (Fahey et al., 1962). Strawberries sprayed for the third time and with one pound active ingredient had residues of 1.1 ppm one day after spraying to 0.3 ppm four days after spraying.

Carbaryl is registered for use on most food crops normally grown in a home garden, often without post-spray harvest limitations. Washing the produce, for example cabbage and eggplant (Mann and Chopra, 1969), effectively reduces the residues. Commercial and home food-preparation methods reduce the carbaryl residues in foods such as tomatoes (Farrow et al., 1968), greenbeans (Elkins et al., 1968), spinach (Lamb et al., 1968), and broccoli (Farrow et al., 1969). Residue reduction in food preparation averaged at least 70 percent in these studies. Development and fruiting of garden produce and agricultural crops will probably not have progressed by late spring, when treatment is proposed.

Carbaryl is registered for control of chicken parasites. Its tolerance level for poultry meat is five ppm. Any deposits reaching birds from the aerial spraying should have no effect on them or their suitability for human consumption. Johnson et al. (1962) report the results of dusting laying hens with exaggerated amounts of carbaryl; no residues were found in the eggs and only traces of residues were found in internal tissues. The skin contained 2.15 ppm at seven days. Carbaryl was placed in the diet of laying hens at the rate of 200 ppm for one week (McCay and Arthur, 1962). No residues of carbaryl were found in the breast, drumstick, gizzard, liver, skin, or eggs in chicken tested three, seven, eight, ten, and fourteen days after treatment.

Carbaryl has not been registered for use on dairy cows because tolerances in milk have not been set. There is some indication that carbaryl as a dust (ten grams of Sevin 50W per cow) or spray (one quart of 0.5% Sevin) can be applied to cows without fear of milk contamination (Camp et al., 1963). When twice the recommended dosage is applied as a spray, residues appeared in milk for the first 24 hours of treatment. In the gypsy moth spray program, cattle are expected to receive even less carbaryl than in these tests.

Small residues were found in tissues of cattle, sheep, and goats one day after spraying (Claborn et al., 1963). At seven days, these residues were eliminated by cattle and sheep, and only small residues remained in the fat and brain of goats. No residues were found in tissue of hogs one day after spraying, and no detectable residues in cattle tissue existed at the end of a 27-day feeding period. The test animals were treated to the point of run-off with a wettable powder formulation. Exposure in the gypsy moth project would be far less, so, no adverse effects resulting from human consumption of livestock are anticipated.

The Federal Environmental Protection Agency expressed the opinion that a one-time application of carbaryl (one pound per acre) "will not constitute an imminent threat to the health of human or other species that may be exposed to the dosage so applied" (Yobs, 1971).

Other Mammals

When fed to mammals, carbaryl is rapidly metabolized and is not stored in the tissue.

Caution is necessary to prevent overdoses of carbaryl over the

treatment areas, but there is no evidence of substantial effects on mammalian populations resulting from one pound of carbaryl per acre. Johnson (1971) indicates that deer, though six to ten times more sensitive than bird species, showed no acute effects. Johnson stated that the U. S. Fish and Wildlife Service prefers carbaryl over more persistent compounds for insect control, yet they are cautious of hazards of carbaryl to wildlife.

Most studies indicate that populations of small mammals are not expected to be seriously affected by the proposed treatment. Small mammals were not adversely affected in total numbers, according to a study made by Barrett (1968), in which he applied two pounds of carbaryl per acre. While some mammals such as cotton rats have been shown to have a reduced reproductive rate, the niches were filled by other species. It is not known how long this species replacement lasts. Other extensive studies (McEwen et al., 1962; USDA, 1964) have failed to show any detrimental effects on small mammal populations. The U. S. Fish and Wildlife Service could provide no data on teratogenic or carcinogenic risks arising from use of carbaryl (Johnson, 1971). Connor (1960) reported that in a test area treated with a single application of carbaryl at one pound active ingredient per acre, the abundance of small mammals, as well as their condition and reproduction of young, seemed unaffected. In a study reported by Willcox (1972) on *Peromyscus leucopus*, the results indicate there were no significant effects on reproductive condition and dispersion of this mammal. Direct mortality was not observed and probably did not occur because total adult catches were similar in treated and check areas.

Birds

No direct adverse effects are expected to occur in bird populations within carbaryl spray areas. Johnson (1971) indicated that exposing birds to low concentrations gives little cause for concern. Acute toxicity levels far exceed normal application rates such as the single pound per acre proposed. The oral LC_{50} for each of several bird species tested was very high, usually around 5,000 ppm; thus, outright mortality of birds from field exposure to carbaryl is unlikely (Heath et al., 1972).

These conclusions are supported by feeding trials conducted on two species of birds that may be found in some of the proposed treatment areas - quail and pheasant. Large amounts of carbaryl in their diets did cause chronic poisoning symptoms in quail - 2,500 ppm in one test and 370 mg/kg/day for 84 days in another test. The average lethal

dose was about 9,250 mg/kg. Reproduction was reduced when quail had ingested a total of 12,000 mg/kg at the rate of 250 mg/kg/day. Pheasants appeared more resistant than quail to carbaryl; more than 40% of the young birds survived after ingesting over 100,000 mg/kg during a 100-day test. Reproduction was reduced approximately 50% by inclusion of 500 or more ppm of carbaryl fed before or during the breeding season (DeWitt and Menzie, 1971).

Observations on 49 species of birds by Connor (1960) failed to reveal any effect on their behavior, conditions, or reproduction and rearing of young. Willcox (1972) in a study of the impact of Sevin 4 Oil on the forest ecosystem found that nestling weight loss as the result of spraying was negligible. This suggests that no drastic food shortage resulted from the treatment. There was some evidence, however, suggesting a connection between the spray and the erratic weight patterns of young robins. The phoebe and barn swallow, both almost wholly insectivorous, did not seem to suffer any adverse effects. Observations suggest no direct mortality occurred to nestlings in the portion of the test area studied. Excessive levels of carbaryl (75-600 ppm in the diet for three weeks) administered to roosters and laying hens in a laboratory study caused embryonic and chick defects (Ghadiri et al., 1967). Carbaryl has been evaluated and registered and is now in general use for control of lice, mites, and fleas on chickens, geese, game birds, pigeons, and turkeys. Egg production, hatchability, and chick survival and growth are unaffected by carbaryl when used as directed for these purposes. Such applications bring more pesticide in direct contact with the bird than native bird populations would receive when the environment they inhabit is sprayed for insect pest control (Union Carbide, 1970).

Extensive monitoring studies (McEwen et al., 1962; USDA, 1964: Stitt, 1966; Connor, 1960) have failed to detect any adverse effects on bird populations after spraying with carbaryl. However, Bednarek and Davidson (1966) reported five young birds dead in a single nest two to three weeks after spraying. It was presumed by Bednarek that the insecticide came to the young birds via the insects brought by the parent for food. There was no confirmatory analysis to determine if death was caused by insecticide ingestion. Careful monitoring of the 1972 gypsy moth suppression operation in Pennsylvania was conducted by USDI Bureau of Sport Fisheries and Wildlife personnel; carbaryl applied as Sevin 4 Oil produced no evident harm to birds (Studholme, 1972b).

An indirect effect of carbaryl spraying on birds may be a depletion of available food which consequently alters bird activity (Doane and Schaefer, 1971). The investigators felt that nestlings may be particularly affected in large spray blocks. They also pointed out the need for more study of the bird-insect control relationship. A study by Moulding (1972) on the impact of carbaryl on forest birds revealed a decrease in bird populations after spraying and a depressing the following year. He believed this was caused by interrelated effects of the insecticide that resulted in some combination of opportunistic feeding outside the spray area, possibly reduced reproductive success, and shift in nest-site loyalty in some portion of the avian community.

Other Vertebrates

Little information is available about the effects of carbaryl on amphibian or reptilian vertebrates. Romine and Bussian (1971) applied six pounds of carbaryl per acre to a small pond containing frogs, and none were noticeably affected. The application rate was considerably greater than the one pound per acre to be used against gypsy moth. In an unintentional triple application of Sevin 4 Oil there appeared to be no adverse effect on frogs or tadpoles (Willcox, 1972).

Soil Fauna

Information is limited on the effects of carbaryl on soil-inhabiting organisms, but it indicates that populations of certain groups of invertebrates will decline initially and will then recover after treatment. Russian studies showed that a half gram per square meter dose of carbaryl reduced the number of soil invertebrates by one-half (Voronova, 1968). One year after the application the total number of soil invertebrates was still lower than for untreated populations. A half gram dosage rate per square meter is nearly equivalent to 4.5 pounds per acre. The dosage rate for gypsy moth is 1.0 pound per acre, and only a small fraction of that reaches the forest floor.

Conflicting results are reported on the effects of carbaryl on earthworms. In a Canadian study of several insecticides carbaryl, applied at two pounds per acre as a wettable powder, had reduced earthworm numbers 59.8% three weeks after treatment (Thompson, 1971). In another study (Moorefield and Borash, 1959), carbaryl applied at the rate of five pounds active ingredient per acre or less was shown to be ineffective against earthworms. Nematodes were not found to be affected by carbaryl in the soil (Welle, 1964).

The effect of carbaryl on living components within a grain crop-grassland ecosystem were investigated by Barrett (1968). A single application of two pounds of carbaryl per acre, twice that to be used in the proposed gypsy moth treatment, was used on a one-acre millet field. A highly significant decrease in soil litter decomposition in the treated area was measured three weeks after spraying, presumed to be the result of a reduction in microarthropods and other decomposers. The total biomass and numbers of arthropods were reduced more than 95% in the treated area and remained well below that of the control area for five weeks; after seven weeks total biomass but not total numbers returned to the control level.

Application of 1 1/4 pounds of Sevin per acre (85% active ingredient mixed with fuel oil) showed no significant effect upon soil mite populations (Stegeman, 1964.). Larger application rates caused greater initial mite reduction and greater rates of increase in late summer. Application rates of 50 pounds per acre did not eliminate the mite populations. In the same study, Collembola populations were reduced by treatments ranging from 1 1/4 to 50 pounds of carbaryl applied alone. The author concluded that 1 1/4 pounds per acre would not influence mites in forest soil, and while some effect on Collembola may be expected, it should be of short duration. Collembola and mites in New Jersey forest soil were exposed to carbaryl in aqueous suspension applied by aircraft at one pound per acre. Mite populations did not change density. Collembola populations declined three weeks after treatment and recovered three weeks later (Moulding, 1972).

Non-Target Insects

Carbaryl is highly toxic to many species of insects inhabiting the forest. Application for the gypsy moth is likely to adversely affect some beneficial insects.

One of the most frequently raised questions concerns the effect of carbaryl on insect parasites and predators in the spray area. It has been proposed that gypsy moth infestations may be prolonged by a combination of excessive reduction of natural enemies and a sufficient residual population of surviving gypsy moth. Although available literature documents some effects of the chemical on certain natural enemies, there has been no study on the population dynamics of major insect enemies in a sprayed area compared with an unsprayed area. Both proponents and critics of the proposed action agree on the high priority need for: (1) studies measuring the effectiveness of natural insect enemies in reducing established as well as pioneer gypsy moth populations; and (2) studies measuring the short-term and long-term effects of gypsy moth treatment on insect enemies of the moth. The latter studies would introduce facts in place of opinions in discussions over long-term population reductions versus outbreak prolongation. Until such studies are made, the significance and magnitude of damage to natural enemies would remain undefined.

In order to acquire this sorely needed information, the Forest Service has contracted with two institutions, conducted a short-term investigation, and is conducting intensive long-term research over a large area. To determine the effectiveness of parasites, a long-term contract was awarded to the Applied Forestry Research Institute at Syracuse, New York; work in 1972 consisted of designing the study and testing sampling procedures. A short-term investigation was carried out by the Forest Service in 1972 in the heavily infested Pocono region of Pennsylvania to learn the intensity of parasitism in the areas where suppression projects have been conducted; the gypsy moth populations, studied only in their larval stage, were healthy and the incidence of parasitism was very low for each of five parasite species recovered and for all of them combined (Hanson and Reid, 1973). The Forest Service long-term investigation in three States is so designed that it should reveal the significance of parasites in natural control of the gypsy moth; data collected to date have not been analyzed.

A short-term contract was awarded to Upsala College at East Orange, New Jersey, to learn the effect on three gypsy moth parasites following suppression with carbaryl; work in 1972 consisted of testing sampling methods.

Some reports have been made on the effects of carbaryl on natural enemies of the gypsy moth. One study revealed that application of one pound of carbaryl per acre in a Sevin 4 Oil formulation did not affect sarcophagid and tachinid flies. Twenty days after treatment, however, Sevin 4 Oil residues were highly toxic to *Calosoma* beetles (Doane and Schaefer, 1971). Susceptibility of those predaceous beetles to carbaryl was noted also in New York when Sevin Sprayable was applied to suppress another forest insect, the saddled prominent (*Heterocampa guttivitta*) (Grimble et al., 1970).

Preliminary data from the Forest Service-contracted parasite monitoring study for effects of carbaryl, applied as Sevin 4 Oil for gypsy moth suppression in New Jersey, (Sellmer, 1972) indicate that populations of the egg parasite *Ooencyrtus kuwanai* were closely similar in numbers and trend in the treated and untreated study areas before and immediately after spraying and until sampling ended in mid-August.

Some indication of carbaryl's effects on non-target insects can be gained from Table 15 prepared by Lilly and Downey (1961). Comparison of results from the three areas revealed that carbaryl caused only a minor decrease of non-target insects.

Table 15. Summary of 1960 catches of eight index species of insects in three experimental areas.

	Area and Treatment		
	Amherst (Unsprayed)	Mt. Toby (Carbaryl)	Cadwell (DDT)
Caripeta angustiorata Wlk. A measuring worm	150	251	49
Estigmene congrua Wlk. A tiger moth	359	256	157
Prochoerodes traversata Dur. A measuring worm	235	210	41
Nadata gibbosa A&S A prominent	252	154	58
Phyllophaga spp. June beetles	337	148	65
Diplotaxis spp. Small scarab beetles	425	590	20
Scudderia septentrionalis Ser. A bush katydid	143	12	2
Ophioninae A ichneumon wasp	260	52	96
Totals	2,161	1,673	488

Non-target forest insects and mites were studied in conjunction with a suppression project in New Jersey (Moulding, 1972). An aqueous suspension of one pound of carbaryl per acre was used. Insect biomass measured by light traps was not affected. Moth numbers and biomass were also not demonstrably changed. Beetles as a group were unaffected in numbers and biomass. Nevertheless, June beetles (*Phyllophaga* spp.) and fish-flies (Corydalidae, Neuroptera) were severely reduced. Too few wasps were present for analysis. Soil Collembola declined but recovered quickly, while soil mites were unaffected. The results suggested that forest arthropods inhabiting the upper forest strata received a greater impact from the insecticide.

The adverse effects of carbaryl on honey bees has been documented by several researchers (Anderson and Atkins, 1958; Anderson, 1964; Arrand and Corner, 1960; Anderson et al., 1962; Moffett et al., 1970). However, New York State has found that the reimbursement for honey bee mortality caused by the application of carbaryl for gypsy moth control is not excessive : about one cent per treated acre (Frommer, 1970; Page, 1970). It was not stated if bee hives were covered or removed from the area. Hives that are removed from carbaryl-sprayed areas during pesticide application and returned a week later do not suffer economic losses (Strang et al., 1968). Recently Sevin 4 Oil was recommended over other carbaryl formulations as a means for reducing honey bee losses (Morse, 1972).

Spider mites are not susceptible (Haynes et al., 1957), but certain other arachnids, such as ticks (Drummond, 1962) and certain mites (Hoyt, 1962), and spiders are susceptible in varying degrees. In one study, phytophagous insects (orders Homoptera and Hemiptera were dominant at the time of spraying) were more severely affected than were predaceous insects and spiders; densities of the latter returned to normal levels within three weeks (Barrett, 1968).

Inasmuch as terrestrial non-target insects, both beneficial and destructive, as well as spiders that inhabit the forest environment to be sprayed, may be killed, three precautionary considerations will minimize their mortality. First, the dosage rate of insecticide is set at the lowest rate that will attain the objective of treatment.

Second, the treatment is timed carefully enough to enable a single application to do what would otherwise require multiple applications. (An exception to this arises when application must be made early to prevent wind dispersal of larvae and later to eliminate the remainder of the population.)

Third, the insecticides proposed for use against the gypsy moth cause adequate gypsy moth mortality at the same time that they cause less harm to non-target organisms than do insecticides used in the past. Domestic bee mortality can be minimized by removing or covering hives in the vicinity of spray operations. No effort can be made at present to insure reasonable protection for wild bees. Lacking is a method for estimating wild bee populations in the forest ecosystem and subsequently accounting for their locations.

Plants. Although carbaryl is not expected to cause damage to leaves of hardwood trees, residues are expected to be present for several weeks. Seventy-eight days after Sevin 4 Oil was applied at one pound carbaryl per acre for gypsy moth suppression in New York, residues in leaves averaged 1.5 ppm. Sevin 80S applied at the same carbaryl dosage rate resulted in leaf residues averaging 1.4 ppm after 80 days (Devine, 1971).

Carbaryl is not expected to have phytotoxic effects in the spray areas other than what might result from inadvertant deposit on the few sensitive plants cited below. Those plants are domestic and should be affected only where growing around dwellings situated under the forest canopy.

Carbaryl applied to tender foliage may cause injury in the presence of rain or several days of high humidity after spraying (Union Carbide, 1962 and 1968a). Spraying in late spring or early summer, as proposed, could conceivably cause damage to apple-tree foliage. Some foliar injury may occur if used before second cover on McIntosh and New York apples (Union Carbide, 1968a). Damage to agricultural plant foliage can be prevented by withholding spray application over garden and crop areas. An additional factor is that fruiting of agricultural crops has not progressed by late spring when treatment is proposed. Boston ivy (Union Carbide, 1968b) and watermelons (Union Carbide, 1968a) can also be injured.

Carbaryl has found a unique application that deserves mention : thinning of apples, thereby preventing limb breakage and providing for higher quality fruit (Horsfall and Moore, 1963; Stebbins, 1962; and Greenhelch, 1960). Carbaryl at the rates of one-half to two pounds active ingredient per 100 gallons of spray reduced fruit set in most varieties of apples when applications were made as late as 25 to 28 days following full bloom (Union Carbide, 1962, and Batjer, 1960). Carbaryl's effects on fruit development of forest tree species, although unknown, are expected to prove unimportant because of low dosage and indications of no effect upon agricultural plants.

Stansbury and Miskus (1964) reported that at application rates of 0.5 to 2.0 pounds per acre, carbaryl has no adverse effect on either plant growth or food flavor.

Aquatic Organisms. In the proposed treatment areas some spray might land on inconspicuous streams and small bodies of water, such as ponds, puddles, and bogs. Buffer strips, in which no spraying is allowed, would be established around larger bodies of water such as reservoirs, lakes, rivers, and estuaries. Despite precautions that would prevent direct spraying of these larger bodies of water, some carbaryl might reach them in the form of drifting spray droplets. The significance these small amounts of carbaryl would have for aquatic organisms is considered in the following pages for fish, invertebrates, and plants.

Fish

Two kinds of information provide insights into the probable effects on fish in the proposed treatment areas: tests and field observations. Conclusions drawn from this add up to one thing: harm to fish is not expected.

Test information on fish must be interpreted carefully because all the conditions present during a test will not be found in the proposed treatment areas and conditions were not standardized in the many reports of tests. Several chemical, environmental, and physical conditions - such as water quality, water temperature, and fish body weight or age - play major roles in determining the acute toxicity of

any toxicant to a particular fish species. One test illustrating this showed that carbaryl is more toxic to brown trout in hard, alkaline water than in soft, acid water (Burdick et al., 1965). The test results discussed below present toxicity information for carbaryl itself on fish and, then, carbaryl compared with some other insecticides.

The toxicity of carbaryl for three species of trout exposed to technical grade (99%) carbaryl was: coho salmon (TL_{50} = 0.7 mg/liter), brown trout (TL_{50} = 1.9 mg/liter), and rainbow trout (TL_{50} = 20.0 mg/liter) (Macek and McAllister, 1969). The toxic level of carbaryl for fingerling brown trout was set at 1.5 ppm (Burdick et al., 1965). Application of carbaryl at one pound per acre directly over open water one foot deep would deliver approximately 0.4 ppm, a concentration that might possibly cause some fish mortality. Compared to its toxicity to cutthroat trout, carbaryl was twice as toxic to brook trout, 1.7 times as toxic to coho salmon, and 1.5 times as toxic to rainbow trout (Post and Schroeder, 1971). Formulated as an aqueous suspension, carbaryl tested on fingerling brown trout proved more toxic than when it was formulated as a suspension in oil (Burdick et al., 1965.)

Compared with other insecticides, carbamates (carbaryl technical, 99%, and Zectran technical, 95%) were less toxic than organochlorines and organophosphates to the 12 species of fish (representing five families) tested (Macek and McAllister, 1969). Compared to DDT, endrin, and malathion, carbaryl exhibited the lowest toxicity to the four species of fish tested - brook trout, coho salmon, cutthroat trout, and rainbow trout (Post and Schroeder, 1971).

Field observations described here cover the spraying of a farm pond and the monitoring of three gypsy moth suppression operations.

A farm pond sprayed with Sevin 80 Sprayable (a water formulation) had no detectable carbaryl in the water two days after it had been sprayed at the rate of six pounds of carbaryl per acre. Sensitivity of the detection method used was 0.03 ppm. Residue immediately after spraying was 4.8 ppm. There was no evidence of any effect on aquatic organisms. Residues in bottom mud disappeared after four days (Romine and Bussian, 1971).

Gypsy moth suppression projects were monitored intensively in 1964 in New Jersey and Pennsylvania and in 1966 in Massachusetts. In the New Jersey and Pennsylvania monitoring work, no fish mortality was observed in the treated area among any of the resident or introduced fish species, which included brook, brown, and rainbow trout. The conclusion was that spraying did not produce conditions in the treated streams which were detrimental to fish (USDA, 1964). The conclusion reached in Massachusetts was that carbaryl had no immediate or long-term effect on fish populations in the ponds treated during the operation. Laboratory tests showed that fish excreted as much as 97 percent of ingested carbaryl in eight hours (Tompkins, 1966). In his report Tompkins stated, "No fish mortalities could possibly occur under normal operating conditions and the investigator does not feel that further monitoring of this pesticide is necessary."

In a recent study on the impact of Sevin 4 Oil on the aquatic ecosystem during gypsy moth suppression in New Jersey, there was no apparent adverse effect on impounded trout or pickerel unintentionally receiving three applications of carbaryl. Also, no adverse effect was observed in green sunfish spawning, nesting behavior or hatchability as a result of the triple application (Willcox, 1972). In two streams deliberately treated with the same insecticide for a USDI study during gypsy moth spraying in Pennsylvania, no harm was observed in the fish under observation - brown trout (Pillow, 1973a).

Conclusions drawn from these tests and field observations indicate that application of carbaryl as proposed for gypsy moth suppression would cause no harm to fish. Any carbaryl landing in water would begin to break down before it could accumulate to high concentrations. Precautions would keep any but small amounts of carbaryl from entering water. An appropriate summary for this subject can be taken from a recently completed analysis of the gypsy moth suppression program as it is carried out by the State of New York. In that analysis, the Federal Environmental Protection Agency included this statement among its conclusions: "The application of carbaryl (Sevin) as a water suspension from aircraft at a rate of one pound per acre to control pests as the gypsy moth, and in consort with current equipment and techniques, policy, regulations, and management does not have significant adverse impact on the aquatic environments" (EPA, 1972).

Invertebrates

Decline, if only temporary, can be expected in some aquatic insect populations after spraying. Population resurgence should, over time, replenish the supplies of these fish-food organisms. The number of aquatic insects - such as stoneflies, mayflies, and dragonflies - may be reduced in those bodies of water that are contaminated with carbaryl (Burdick et al., 1960; USDA, 1964; Coutant, 1964; Pillow, 1973a); no adverse effect was seen where streams were avoided (Felley, 1970). The population depression will vary with the degree of contamination. Inasmuch as contamination of these non-target areas should be minimal (USDA, 1964) and because the spraying involves a single-dose, single-application approach, the aquatic organisms should suffer only a temporary depression, if any.

A study by Barker (1964) showed that when carbaryl is applied aerially at one pound per acre, it is detrimental to larval mayflies and stoneflies to the extent that their populations are substantially reduced in and immediately below the sprayed area. No apparent toxicity to caddisflies or other orders of insects was suggested. Burdick et al. (1960) also noted that carbaryl (in oil suspension) was found highly toxic to mayflies and stoneflies. Unlike Barker (1964), Burdick et al. (1960) found that carbaryl was also highly toxic to caddisflies. Other groups of aquatic insects were apparently less affected over short exposure periods. A progressive effect on insect populations from upstream to the lower sections of a spray block downstream was believed to have been correlated with increased exposure time. Willcox (1972) found no apparent toxicity of carbaryl (Sevin 4 Oil) to damselflies and dragonflies in a study in New Jersey.

In 1973, Pillow (1973b) revisited Pennsylvania test streams that had been deliberately treated in 1972 with carbaryl applied as Sevin 4 Oil. That severe treatment had practically eliminated aquatic insects from the sprayed parts of the streams shortly after the insecticide was applied (Pillow, 1973a). The 1973 sampling revealed that both test streams again contained normal populations of aquatic insects. Of particular interest were the results of bottom samples taken in the carbaryl-sprayed streams. There was a complete repopulation of benthic organisms, which had been almost decimated the previous year.

The severity of the reduction of certain aquatic insects, recognized important fish-food organisms, upon the fish production and fish holding capacity of the affected portion of the stream depends upon many factors. On the basis of his field work, Barker (1964) concluded: "Because of the general adaptability of most fish species, this reduction in fish-food organisms is not expected to seriously affect either the production or fish holding capacity of the stream in or below the treated area."

Carbaryl had no immediate effect on shellfish populations exposed to gypsy moth spraying on Cape Cod (Tompkins, 1966), indicating that carbaryl can be applied with sufficient care to prevent marine shellfish losses.

Crustacea can be seriously affected or killed by 24-hour exposure to carbaryl concentrations of from 0.03 to 1.5 ppm; the 48-hour TLm for white shrimp is 13 ppb in sea water (Flores and Fairchild, 1968). Dungeness crab have suffered mortality and paralysis from carbaryl (Buchanan et al., 1970). At 1.0 mg/liter, hatching was not prevented; molting was inhibited in all prezoeae. Early growth stages displayed disrupted molting when exposed to 0.0001 mg/liter. The concentration at which fifty percent of first stage zoeae can be expected to die during a 96-hour exposure is estimated at 0.1 mg/liter. Zoeae survival after 25 days exposure was reduced by concentrations as low as 0.00032 mg/liter. Young juvenile crabs are more sensitive to carbaryl than are older juveniles and adults.

Mollusk larval and adult growth rates are seriously affected by continuous exposure to concentrations of 1.0 to 1.5 ppm (Flores and Fairchild, 1968). Cockle clams have survived 96 hours at carbaryl concentrations as high as 1.80 mg/liter (=1.80 ppm), but they did not survive a similar time span at 1-naphthol concentrations above 0.56 mg/liter (Butler et al., 1968). The 96-hour TLm's were determined as 3.75 mg/liter for carbaryl and 2.70 mg/liter for 1-naphthol. Oyster eggs at carbaryl concentrations of 1.0 ppm have undergone 40% reductions in numbers reaching the normal "straight hinge" stage, and at 5.0 to 10.0 ppm normal egg development was entirely prevented (Davis, 1961). An accelerated growth effect from carbaryl at lower concentrations (1.0 ppm) has been observed for larvae of clams and oysters (Davis and Hidu, 1969).

In general, 1-naphthol is generally more toxic to fish and shellfish than carbaryl itself (Butler et al., 1968; Lamberton and Claeys, 1970; and Stewart et al., 1967).

The above data regarding marine invertebrates indicate a need to avoid direct or indirect application of carbaryl to marine ecosystems. Precautionary measures must be sufficient to prevent surface or subsurface runoff as well as atmospheric drift of carbaryl (or 1-naphthol) into brackish or sea water. Despite carbaryl's degradation, the 1-naphthol can form a more persistent precipitate in sea water and can be toxic to estuarine species (Lamberton and Claeys, 1970).

Plants

The higher aquatic plants are not expected to sustain any detrimental effects from the proposed carbaryl application. Phytoplankton, however, might be affected by carbaryl if, through contaminated water runoff, concentrations reach 0.1 ppm (USDI, 1960).

In another study, carbaryl at 1 ppm did not seriously affect growth of three resistant species of phytoplankton but two others were completely suppressed (Ukeles, 1962). Concentrations of 10 ppm were lethal to three species.

Effects of carbaryl on freshwater species of algae may be reflected in results of a test with *Scenedesmus quadricaudata*. Carbaryl did not harm the organism, but instead stimulated its growth, possibly through increased availability of nitrogen produced by the metabolism of carbaryl in water. This might cause a bloom of algae in fresh water receiving enough carbaryl (Stadnyk and Campbell, 1971).

Non-Living Entities.

Water Supplies

Low concentrations of carbaryl are expected to reach some water supplies in the treated areas. The following review of previous studies suggested that levels dangerous to man will not result.

Several studies have been conducted to determine carbaryl residues in streams and ponds. In a two-year study (Fahey et al., 1968) where carbaryl was applied to a field to control the alfalfa weevil, periodic pond-water samples, in one instance, displayed a carbaryl residue at twice the minimum detectable residue of 0.001 ppm (=1.0 ppb). Concentrations of carbaryl in two creeks within a gypsy moth treated area in New Jersey averaged 30 ppb on the day of treatment, 1.5 ppb the following day and 1 ppb six days later (USDA, 1964). In a similar study on Cape Cod, samples collected at intervals after spraying showed small amounts of carbaryl ranging from .001 to .003 ppm (Boschetti, 1966). In 1971, samples of water and pond mud were collected after carbaryl application against gypsy moth in New York (Devine, 1971). Applications of Sevin Sprayable and Sevin 4 Oil were made at the rates of one pound active ingredient per acre. Carbaryl residues in ponds and streams ranged from non-detectable levels to 0.05 ppm during an 8-day period following spraying. Residues in pond mud ranged from non-detectable to 0.62 ppm.

In another study, two ponds (about 30 acres each in size) were exposed to an aerial spray application of undiluted Sevin 4 Oil at a rate of one pound active ingredient per acre (Romine, 1971). Water samples were taken from the ponds and analyzed for carbaryl residues. The initial residue of about 0.5 ppm had almost disappeared in four days. The maximum residue at four days was 0.05 ppm and water samples taken at eight days after spraying revealed residues of 0.01-0.02 ppm. Application of Sevin 4 Oil applied at one pound carbaryl per acre resulted in a rapid and complete dissipation of residues from the study watershed within a maximum of ten days, and generally within 48 hours (Willcox, 1972).

Felley (1970) hypothesized that several things could happen to carbaryl to account for the fact that it is not detected in very large amounts in streams within treated areas. It is possible that a great amount of the material could "be converted to plant-stable conjugates, metabolized or volatilized by plants and microorganisms, chemically altered by sunlight and enter the streams as nontoxic water-soluble compounds."

The attitudes of two major nations, the USA and the USSR, toward carbaryl residues in water are reflected in the tolerances they have recommended. A study in Russia for a hygienic tolerance for carbaryl in bodies of water recommended concentrations not to exceed 0.1 mg/liter (=0.1 ppm, =100 ppb) (Gabrilevskaya et al., 1965). In the United States, public health tolerances have not been set for carbaryl alone in all drinking water. However, the tolerance on organic phosphates <u>plus</u> carbamates has been set at 0.1 mg/liter of water (US Dep. HEW, 1968).

For untreated raw ground water supplies, the U. S. Public Health Service (US Dep. HEW, 1968) established 0.035 mg/liter (=0.035 ppm, =35 ppb), as the maximum permissible concentration of carbamate compounds for domestic or food processing uses. Careful application of carbaryl should preclude ground water carbaryl concentrations of 0.035 mg/liter and over.

Soil

Insecticide residues are concentrated in the upper three inches of soil (Lichtenstein et al., 1962). The results of the analysis of soil samples collected before a gypsy moth spray program on Cape Cod showed that carbaryl was initially present in the soil in concentrations ranging from 0.008-0.022 ppm. Such measurements may represent method sensitivity rather than a measure of carbaryl

present. Samples collected at unspecified intervals after spraying showed concentrations of carbaryl ranging from 0.018-0.300 ppm (Boschetti, 1966). Soil samples taken over a 16-day period following the application of one pound of carbaryl per acre resulted in residues that ranged from non-detectable to 3.2 ppm (Devine, 1971). In another study, soil samples were taken in conjunction with an alfalfa weevil control program employing carbaryl as a 50% wettable powder suspension at three pounds per acre (Fahey et al., 1968). Residues ranged from 0.006 ppm before application and 0.114 ppm one day after spraying to no detectable amount five months after treatment. No adverse effects are known from these studies.

Man's Objects

Neither Sevin Sprayable nor Sevin 4 Oil causes damage to automobile finishes (including acrylic lacquers). As an extra precautionary measure, however, cars can be washed with warm water and a mild detergent immediately after spraying (Union Carbide, 1971).

ADVERSE EFFECTS OF TRICHLORFON, INCLUDING ANY THAT ARE UNAVOIDABLE

The same general precautions that applied to carbaryl need to be observed with the use of trichlorfon. Careful spray timing, buffer strips around bodies of water, and adherence to previously mentioned spray mechanics should minimize environmental contamination to non-target areas. As a result of similar spraying with trichlorfon in New York and Pennsylvania in 1971 and 1972, no major adverse effects are known to have occurred.

Terrestrial Organisms.

Man and his Food

Trichlorfon, because of its low toxicity to man, has been used as a therapeutic drug in Africa and South and Central America for the control of intestinal parasites and schistosomiasis (Abdalla et al., 1965; Beheyt et al., 1961). In studies with trichlorfon in Africa to control *Schistosoma haematobium* infections in humans, rates of 5-15 mg/kg of body weight showed no major side effects (Davis and Bailey, 1969). Neither excessive dosages of over 24 mg/kg nor, in the case of one individual, 72 mg/kg of body weight resulted in serious accidents in patients being tested for trichlorfon therapy (Wegner, 1970). In the same study, the side effects of the chemical did not last long or cause irreversible damage.

Mammalian dermal toxicity of trichlorfon is so low that a dermal LD_{50} value could not be obtained (Chemagro, 1968).

With its low oral and dermal toxicity, trichlorfon should not pose any problem to mammals as a result of its application. Because of the safety of trichlorfon to animals, it is registered for the control of many ectoparasites and endoparasites of livestock. One formulation is used as a wormer on horses.

Birds

In a test by DeWitt et al. (1960), trichlorfon was reported more toxic to quail and pheasants than carbaryl. The LD_{50} for pheasants, for instance, with trichlorfon was 2,500 mg/kg, while with carbaryl it was over 40,000. The maximum trichlorfon concentration in the diet permitting normal survival was 100 ppm for quail and 500 ppm for pheasants. In a bobwhite quail feeding test, at a level of 134 ppm (approximately 2 pounds of trichlorfon per acre), brain acetylcholinesterase inhibition was 38% after 24 hours' exposure, 48% after 48 hours, and 63% after 96 hours (Pillmore, 1971). Pillmore went on to describe field applications of 1 pound trichlorfon per acre; no evidence was found of any avian toxication or mortality following spraying. No striking evidence of adverse effect upon resident birds was observed, but some avoidance of the sprayed area by non-resident birds was suspected but not confirmed.

Investigations by USDI (1962) revealed quantities of Dipterex, a trichlorfon formulation, causing 50% mortality for the young of two species of birds tested for less than ten days (Table 16).

Table 16. Dipterex LD_{50} for the young of two bird species.

Species	ppm in diet	mg/kg eaten
Bobwhite	750	425
Ringneck pheasant	5,000	2,500

A typical example of trichlorfon for a crop use is its use on beans at 1-1 1/2 lbs/acre. The tolerance is 0.1 ppm with the stipulation that it should not be applied within 14 days of harvest (Chemagro, 1972a). Trichlorfon is registered for use on beef and dairy cattle for the control of parasites. The tolerance is 0.1 ppm for meat, fat, and by-products of cattle, while the tolerance for milk is 0.01 ppm. The insecticide is not to be used for lactating cattle, within 14 days of slaughter, or on cattle under 3 months old (EPA, 1969).

The dermal LD_{50} of trichlorfon to the rat is so high it could not be determined, but at least it was learned that it is over 2,500 mg/kg of body weight. It can be calculated that at the dosage rate of one lb/acre which is planned for some of the suppression proposed for 1973, a person occupying two square feet of area would receive a dosage of only 21 mg of trichlorfon.

Other Mammals

Chemagro Corporation (Chemagro, 1971a) reports the oral LD_{50} of trichlorfon for rats is 450-500 mg/kg of body weight. This is comparable to carbaryl, which has an LD_{50} of 540 mg/kg (Metcalf, et al., 1962).

Chemagro (1971b) reported an example of effects that can be expected on large mammals; when trichlorfon was administered to a bull elk at the rate of 30 mg/kg per day for six days, the animal showed signs of severely depressed cholinesterase level on the sixth day of treatment. In a field study, Chambers (1972) found no dead mammals on any of the plots sprayed with Dylox 80% SPA in oil at 1 lb active ingredient per acre. The mammal populations were contaminated with trichlorfon, but no effect of this contamination in the population was observed. A new York field study of the total effects of an aerial application of trichlorfon on the white-footed mouse (*Peromyscus leucopus*), a predator of the gypsy moth, revealed no observable effects (Caslick and Smith, 1973). Dylox 80% SPA in oil was applied at one pound trichlorfon per acre. Residues were detected in four of ten mice collected six weeks after spraying. Trapping gave no indication of an age-selectivity effect from the insecticide, and catch rate reflected the expected seasonal increase in mouse abundance. Of 59 mice marked before spraying, 17 were still being trapped at six weeks, and some were still being re-trapped when the study ended seventeen weeks after spraying.

Abundance did not return to the pre-spray level during the following five weeks. The investigators judged that bird activity probably was reduced because the insecticide depleted the available food supply. Nesting activities continued on the area after treatment. Young birds fledged from about half of the nests observed; in the remainder, more than half the nest desertions were attributed to causes unrelated to the treatment. No bird mortality was attributable to the trichlorfon treatment.

In a study in Pennsylvania, Studholme (1972a) indicated that no demonstrable hazard to the several bird species inhabiting the study area resulted from Dylox 80% SPA in oil applied at the rate of one pound trichlorfon per acre. Residue and acetylcholinesterase analyses performed on specimen birds from the spray area indicate that trichlorfon did not present a significant hazard to wild birds.

The studies indicate that trichlorfon does not have a direct effect on bird populations in spray areas. It may, however, temporarily alter bird activity through the depletion of available food supplies.

Non-Target Insects

The toxicity of trichlorfon to bees was classified low by Johansen (1959). Years of commercial use since then confirmed that trichlorfon is relatively non-toxic to honeybees, and presumably other pollinators, particularly at minimum dosages required for gypsy moth control. In controlled experiments, trichlorfon was applied as a dilute spray at five gallons per acre, and as a low volume spray at one quart per acre. Based on the number of dead bees in hives and on field visitation counts, no significant differences in bee toxicity were noted between treated and untreated plots (Chemagro, 1968). A ten-acre field of seed alfalfa was treated with undiluted trichlorfon at one pound active ingredient per acre. Samples of foliage were taken 12 and 36 hours after application and caged with 25 to 50 honey bees. Twenty-four percent mortality of honeybees occurred with 12-hour foliage residues, 4% at 36 hours, and from 1-6% in untreated controls (Chemagro, 1968). Others confirmed (Merriam et al., 1970; Gilpatrick et al., 1970) that trichlorfon applied as a ULV formulation did not have an adverse effect on honey bee populations.

USDI (1960) reported the approximate lethal dose and levels of Dipterex in diet that reduced reproduction 25% or more for the same two bird species (Table 17).

Table 17. Approximate lethal dose of Dipterex and dosage affecting reproduction.

Bird	Approximate lethal dose (mg/kg)		Level in diet reducing reproduction 25% or more (ppm)
	Young	Adult	
Bobwhite	600	>4,000	25
Pheasant	2,600	>800	25

Pearce (1970) in New Brunswick reported that two aerial applications of six ounces of trichlorfon per acre did not present a significant hazard to the American redstart, Tennessee warbler, and Blackburnian warbler. Chemagro Corporation (1971b) reported that in a study where one pound trichlorfon per acre was applied, doves, quail, blackbirds, and meadowlarks were observed before, during, and after spraying and appeared unaffected by the application. Doane and Shaefer (1971) concluded that trichlorfon caused a depletion of the available food, which altered bird activity. The overall effect was increased bird activity in the areas outside the spray plots. The birds were not directly affected by the insecticide treatment, however.

In a 1971 study in New York (Chambers, 1972), no dead birds were found in any of the plots treated with trichlorfon at one pound per acre. Eight caged birds survived their period of exposure with no evidence of tremors, convulsions, or behavior suggestive of poisoning. In a 1972 study in New York, Caslick and Cutright (1973), found no dead or disabled birds in the study area during a 48-hour intensive search following application of Dylox 80% SPA in oil at one pound trichlorfon per acre. Considerable decrease in bird abundance was noted following the treatment.

to pre-treatment levels within several weeks after application. Due to its low toxicity to bees, their colonies do not have to be removed from spray areas. Trichlorfon applied at rates used for control of the gypsy moth should not cause a significant effect on non-target insects.

Plants

Preliminary test results provided by Chemagro (Garner, 1971) indicate that leaf spotting by Dylox 80 SPA plus oil at from one to four pounds per acre was very slight or non-existent on mums, roses, marigolds, and three vegetables. Similar data for forest plants are not available. However, no adverse effects have been noted during forest spraying operations.

Aquatic Organisms.

Fish and other Vertebrates

In a test by Pickering et al. (1962) trichlorfon was found to be the safest organic phosphorus formulation administered to fathead minnows and bluegills. In a test by Hoffman (1957) trichlorfon did not affect fingerling and legal-size rainbow trout exposed for 24 and 72 hours to 1.0 and 10.0 ppm. After the toxicant was discontinued, the fish were held for at least 48 hours for observation of possible delayed effects. Chemagro (1971), however, reported that fingerling rainbow trout exposed to concentrations of 10.0 ppm died within 24 hours. Matton and Laham (1969) studied the effect of Dylox on rainbow trout. They treated 1-inch rainbow trout for 16 hours with from 10-100 ppm trichlorfon or for 40 hours with 5 ppm. This treatment produced a marked acetylcholinesterase inhibition that was reflected by their abnormal behavior pattern. Histological examination revealed pathological changes which could not be explained on the basis of acetylcholinesterase inhibitions. Lewallen and Wilder (1962) fed rainbow trout 1.0 and 10.0 ppm and found no harmful effects or mortality at 24, 48, and 72 hours.

Hornbeck et al. (1965) used applications of 0.25 ppm trichlorfon to control fairy shrimp inhabiting ponds. Results indicated that large mouth bass and channel catfish, bass and bluegill were unaffected by the treatment. Weiss (1961) stated that trichlorfon at a concentration of 1.0 ppm caused 50% mortality of golden shiners after six hours.

In recent tests on alfalfa and cotton, application of Dylox ULV at rates as high as one pound active ingredient per acre caused substantial reductions in populations of certain beneficial insects such as big-eyed bugs, damsel bugs, and ladybird beetles. In general, however, populations of these insects returned to pretreatment levels within one to two weeks following application. Regardless of spraying techniques used, beneficial insect populations returned to normal (Chemagro, 1968). Lingren et al. (1968) reported that trichlorfon applied at a rate of 0.25 to 0.5 lb/acre did not adversely affect predators of cotton bollworm.

Stern et al. (1960) reported that a trichlorfon formulation applied at 11.4 oz/acre resulted in a reduction of approximately 66% ladybird beetle adults and nearly 90% ladybird beetle larvae one day after treatment. Using the same dosage rate of Dylox, a 50% reduction in *Chrysopa* spp. adults and *Geocoris* spp. adults and nymphs was attained. Populations of *Nabis ferus*, *Orius* sp. and P. *palitans* were considerably reduced. at 5.7 oz/acre there was severe reduction of ladybird beetles, *Orius* sp., and nymphs of N. *ferus*. At 7 oz/acre, syrphid fly adults and larvae were largely eliminated. A 50% reduction of the adults of *Orius* sp. was attained at 3.6 oz/acre.

Stern (1963) showed trichlorfon is not basically as toxic to *Trichogramma* parasites as carbaryl. Mortality with carbaryl was 95%, while trichlorfon caused only 10% mortality of the parasites. Also, trichlorfon was less toxic to the three predators *Geocoris* spp., *Nabis ferus*, and *Orius tristicolor*.

Sarcophagid and tachinid flies were reduced significantly in numbers (approximately 90%) by trichlorfon (Doane and Schaefer, 1971). The treatment did not seem to affect the mosquito or deer fly activity in the plot, however. The insecticide was toxic also to non-target Lepidoptera, mainly leaf rollers and loopers. *Calasoma frigidum* exposed to Dylox spray was only slightly affected by the treatment (Grimble, 1972a). Members of the genus *Calosoma* are important predators of the gypsy moth.

Trichlorfon exhibits low toxicity for honeybees, *Trichogramma* spp., and *Calosoma* spp. It is toxic to sarcophagid and tachinid flies and certain hemipterous predators, but these insects return

In a stream deliberately sprayed with Dylox 80% SPA in oil at one pound trichlorfon per acre, the USDI observed no harm to the fish species studied - white suckers and brook trout (Pillow, 1973a).

Fishes and frogs in three different aquatic environments in New York were studied in 1972 to learn the effects of an aerial treatment of Dylox 80% SPA in oil applied at one pound trichlorfon per acre (Finger and Werner, 1973). The investigators concluded that the insecticide had no significant immediate impact on the aquatic vertebrates studied. The highest residues detected, which were found in the first sample (taken at 12 hours post-spray), were well below acutely toxic levels in all sites. By 96 hours post-spray, levels had declined to near or below the limits of detection (limits were 2 ppb for lake fish, 30 ppb for tadpoles, and 9 ppb for stream fish). No species differences were found in levels of trichlorfon accumulation. Residues in lake fish were approximately one-tenth those in the stream fish and one-fifth those in pond tadpoles, possibly because spray dilution was greater in the lake. No significant pre- or post-spray changes were found in population size, survival rate or accretion rate for tadpoles. Fish mortality was limited to brown bullheads. The cause of the death is unknown, but the investigators judged that trichlorfon was not the cause.

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The LC_{50} for three fish species was reported by Pimentel (1971) (Table 18).

Table 18. LC_{50} of trichlorfon for three fish species.

Fish Species	Exposure time (hr.)	LC_{50}(ppm)
Striped bass	24	10.4
Rainbow trout	48	3.2
Fathead minnow	96	180.0

Trichlorfon has a low enough toxicity for fish that it is registered for fish parasite control in Germany. Masoten(R), a soluble powder which is 50% trichlorfon, is currently in the registration process in the United States for control of anchorworms, lice, and gill flukes on bait fish and goldfish (Chemagro, 1972b).

Because of its demonstrated relative safety, trichlorfon should not adversely affect fish or frogs as a result of gypsy moth spraying.

Invertebrates

Carlson (1966) reported that the 24-hour TL_m for mayfly and caddisfly larvae is only 0.91 and 0.017 ppm. This would suggest that care should be taken near streams where these two insects need to be preserved.

Davis (1961) reported there was a significant reduction in growth of oyster larvae at 0.025 ppm. At 1.0 ppm, mortality of the larvae reached almost 50%. In tests with trichlorfon at 0.25 ppm for fish parasite control, Hornbeck et al. (1965) found that it had an adverse effect on tadpole and fairy shrimp.

In a 1971 study on the impact of Dylox 80% SPA in oil applied at one pound of trichlorfon per acre on an aquatic environment, Judd et al. (1972) found that of 38 species of invertebrates present, a statistically observable change in density occurred only in the two species *Musculium* and *Sphaerium* (Pelecypoda). These two species were probably affected because they filter large amounts of water through their shells for normal feeding and respiration. The authors concluded that trichlorfon appeared to have no significant effect on benthic organisms in the lake or stream.

In another study of Dylox 80% SPA in oil, parts of two streams sprayed deliberately in 1972 for the USDI at one pound trichlorfon per acre resulted in a small increase in drift of aquatic arthropods immediately after spraying (Pillow, 1973a). These streams were revisited in 1973 and contained their normal populations of stream bottom insects one year later (Pillow, 1973b). Macroinvertebrates in nearly all 1973 samples were greater in total number than corresponding samples the previous year. This is thought to be due to natural variation. In 1973 the USDI also monitored a test of Dylox 1.5 Oil in Pennsylvania, conducted to compare results of 1/2 lb and 1 lb application rates. Both rates "produced no detectable pattern of change in numbers or composition from the baseline of normal occurrence" (Pillow, 1973c).

Aquatic insects in New York streams were studied in 1972 to learn the effects of gypsy moth suppression treatment with trichlorfon : one pound per acre formulated as Dylox 80% SPA in oil, applied by aircraft (Todaro and Brezner, 1973). The investigators concluded that the treatment produced no significant effects on totally submerged aquatic insects as evidenced by bottom, drift, and lake sampling. Statistical comparison between treated and untreated streams showed no significant differences in numbers of insects collected. The stoneflies, caddisflies, and mayflies found in these streams seemed to be unaffected by the spray. The data indicate that their numbers remained stable, with minor increases occurring within 24 hours of each heavy rain storm.

Plankton

A comparison of trichlorfon with carbaryl indicates that trichlorfon is less toxic to phytoplankton. The Fish and Wildlife Service (USDI, 1960) stated the highest concentration of trichlorfon tolerated by five kinds of phytoplankton was 10,000 ppm. They also (USDI, 1962) reported that an exposure of 1 ppm trichlorfon had no effect on the productivity of phytoplankton, whereas carbaryl reduced productivity by 16.8%. Trichlorfon has no effect on phytoplankton even at concentrations as high as 10 ppm (Chemagro, 1968). However, zooplankton populations were seriously reduced when a 0.1 acre pond was treated at 1 ppm for four weekly applications, although at 0.25 ppm, the populations were not affected (Chemagro, 1971b). When trichlorfon was coated on fish feed at 2,500 and 4,000 ppm for sixteen weeks, rotifers were not affected but Cladocera were eliminated; and some copepods, particularly the anchor parasite, *Lernaea cyprinacea*, were substantially reduced (Chemagro, 1971b).

Trichlorfon appears to be safe to phytoplankton but may seriously reduce zooplankton at 1 ppm. It is also toxic to Cladocera and the fish anchor parasite, *L. cyprinacea*.

Non-Living Entities.

Man's Objects

Dylox ULV does cause damage to the acrylic finish of General Motors and other makes of cars. This is the most significant limiting factor restricting its use in areas used by people, the very areas that support the greatest interest in spraying gypsy moth. A new formulation of Dylox (Dylox 1.5 Oil insecticide) has been developed. It does not damage cars but may have a longer residual life than Dylox ULV.

ADVERSE EFFECTS OF *BACILLUS THURINGIENSIS* INCLUDING ANY THAT ARE UNAVOIDABLE

Tests indicate that no adverse effects should be expected from using *B.t.* as a suppression material for gypsy moth control. It has shown no adverse effects on wildlife, birds, mammals, fish, and invertebrates - except for lepidopterous insects.

Terrestrial Organisms.

Man and his Food

International Minerals and Chemical Corporation compiled test results showing that *B.t.* is not harmful to man (IMC, 1969). Swine fed *B.t.* in their diet for almost two years showed no toxic symptoms. No dermal or eye toxicity has been found in laboratory tests. *B.t.* is exempt from tolerance on food and feed.

Other Mammals

Test results assembled by International Minerals and Chemical Corporation indicate that *B.t.* has no adverse effect on wildlife (IMC, 1969). Doane and Hitchcock (1964) stated that *B.t.* appeared to cause negligible damage to vertebrate wildlife.

Birds

One long-term study with six New Hampshire Red laying hens was conducted over a 23-month period. The hens received a daily dose of *B.t.* ranging from 0.5-10 gms per bird. Results showed no allergic response, other illnesses, or variations in the expected egg production of the hens on test diet. There was no significant difference between the test birds and the birds used as controls. In a nine-week oral toxicity test administered to 24 groups of 10 chicks each, no significant differences of any kind were noted between the test and control groups of chicks (Fisher and Rosner, 1959).

In a test by Briggs and Goodrich (1959), 17 pheasants and two partridges, all about six weeks old, were divided into two groups. One group was fed 1.0 gm of *B.t.* per bird per day in two gelatin capsules. The control groups were fed two empty gelatin capsules daily. No deaths or symptoms of respiratory, alimentary or other disturbances were noted in the *B.t.* fed group. Two pheasants

in the control group died of trauma (due to handling). Birds in both groups exhibited feather color and pattern, bearing and weight gain that is expected in similar groups of birds in nature. It was concluded that no differences in behavior or development of test birds resulted from the ingestion of 1.0 gm of *B.t.* spore-crystal complex per bird per day when compared to the control group.

An oral acute toxicity study conducted with *B.t.* in young adult bobwhite quail showed the acute oral medial lethal dosage exceeded 10 gm/kg body weight (IBT, 1970b). Five male and five female quail were fed gm/kg by gavage. A similar group was fed distilled water as control. At the end of the 21-day test period, all the animals were sacrificed and subjected to a gross pathological examination. No pathology attributable to the test material was found. Growth rate was similar in the test and control groups.

Non-Target Insects

Numerous tests with several serotypes of *B.t.* showed no deleterious effects on bees where practical dosages were used. Heat stable exotoxin is poisonous to bees, as are high concentrations of spores (Bailey, 1971).

The silkworm is highly susceptible to *B.t.*, particularly var. *thuringiensis*. Because of this, it is illegal to disseminate foreign preparations of any pathogen in Japan (Bailey, 1971).

Effects at an unknown level are presumed to occur to all lepidopterous larvae that contact and ingest *B.t.*

Aquatic Organisms.

Fish

Several acute toxicity tests were conducted on fish with *B.t.* preparations. A four-day fish toxicity study was conducted with *B.t.* employing rainbow trout and blue gills as test animals. Two groups of ten fish each were placed in water containing *B.t.* at concentrations of 560 and 1,000 ppm. None of the trout or bluegills died (Fisher and Rosner, 1959). Rainbow trout - four inches in length - were exposed to *B.t.* at concentrations of 100-1,000 ppm for 14 days. No deaths resulted, nor were any symptoms of alimentary or behavioral disturbances evident (Fisher and Rosner, 1959). In a test with juvenile coho salmon

(1.6 inches in length), *B.t.* was about 1/30 as toxic as DDT. The tests ran for 168 hours with concentrations of 8-406 mg *B.t.* per liter of water. The 48 hour median tolerance limit of the *B.t.* was about 50 mg/liter (Fisher and Rosner, 1959).

Invertebrates.

Doane and Hitchcock (1964) found that *B.t.* caused negligible damage to aquatic insects.

VI. ALTERNATIVES TO THE PROPOSED ACTION

The selection of prospective treatment materials involved evaluation of the following "apparent" alternatives. They were ruled out due to various limitations for use as operational control measures in suppression and regulatory work, although they may be used for operational tests. They are discussed below.

ACEPHATE (ORTHENE$^{(R)}$)

Acephate is a moderately persistent organophosphorus insecticide, with local systemic activity and it has shown efficacy against a number of lepidopterous insects, including the gypsy moth. Currently, it is registered for homeowner use to control a broad spectrum of insects on ornamentals, trees, shrubs, and flowers.

Acephate has a low acute oral mammalian toxicity : 900 mg/kg (rats) (Chevron, 1973). It has a low toxicity to fish; the 96-hour TL_{50} ranged from 1,725 ppm for the most susceptible species tested (black bass) to 9,550 ppm for the least susceptible (gold fish) (Chevron, 1973). These values show a lower toxicity than either carbaryl or trichlorfon. Acephate is, however, reported to be slightly more toxic to bees than carbaryl (Chevron, 1973).

The insecticide's effects on the environment are minimal. For example, in plants 90-95% of applied acephate is degraded directly into innocuous salts, and 5-10% to Monitor$^{(R)}$ (Ortho 9006), a closely related insecticide. This is the only metabolite of toxicological significance. Field and laboratory studies have shown that acephate and Monitor are rapidly degraded in plants and water (Chevron, 1973). Generally, a 5-10 day half-life has been noted in plants (Chevron, 1973). Willcox (1973) reported from applications of up to 1/2 lb per acre that residues in leaves and litter dropped below the 0.02 ppm limit of detection in 33 days. In a test of persistence in surface water, acephate applied at 0.1 ppm dropped below that level within a week and was essentially zero by 6 weeks (Chevron, 1973). Many things influence the persistence of acephate in soil, causing wide variation in its residual life. The major degradation mechanism is biological activity. For agricultural soils, the generalization is made that there will be no build-up of either acephate or Monitor from one growing season to the next (Chevron, 1973).

Willcox (1973) examined the effect of acephate applied aerially at 1/2 lb/acre on the organisms inhabiting a typical pond and stream ecosystem. No dead frogs, fish, newts, snakes or tadpoles were observed at any time during the study period. Also, from preliminary data analysis, there appears to be no severe effect or significant depression of numbers to the stream benthic organisms, fish, frogs or snakes.

Information to date shows that acephate is of low toxicity for non-target organisms, except for Lepidoptera and some Hymenoptera. This, along with its rapid degradation in the environment, indicates that acephate used according to label directions poses little or no hazard in the forest environment and is a good candidate insecticide for further field investigation.

GARDONA(R)

Gardona is an organophosphate insecticide which has been effective in providing foliage protection against the gypsy moth (Doane and Schaefer, 1971; Doane, 1968). A 75% wettable powder formulation is currently registered against the gypsy moth by ground and aerial application methods.

The Forest Service conducted a field test in 1972 using Gardona 75% wettable powder applied by helicopter to determine efficacy of the two dosage rates tested (1 and 1.5 lbs/acre) and the residual activity of the insecticide. Barger (1973) reported the summary of treatment results in the following table (Table 19).

Table 19. Results of a field test of Gardona 75% WP for gypsy moth control in Pennsylvania in 1972.

Treatment	Avg. egg masses/acre		Avg. % defoliation		
(Lb AI/acre)	Pre-spray	Post-spray	Pre-spray	Post-spray	Net increase
1.0	960	2,936	7	23	16
1.5	1,601	3,992	10	28	18
None	1,214	5,540	8	34	26

The data show that neither treatments of 1.0 nor 1.5 lbs Gardona per acre were effective in reducing the population or defoliation. There was a 2 1/2- to 3-fold increase in egg masses in the treatment areas. The average net increase in defoliation in the treatment blocks was only slightly lower than in the check plots.

As demonstrated by the 1972 field test, this insecticide is not a viable alternative for suppression projects involving aerial application.

IMIDAN(R)

Imidan is an organophosphorus insecticide registered for ground application against the gypsy moth but not for aerial application. Imidan 50-WP, because it is a wettable powder requiring water as a carrier, is more difficult to mix and apply than liquid formulations.

Information that is comparable indicates that Imidan is more toxic to rats and rainbow trout than carbaryl and trichlorfon. The LD_{50} of Imidan to the rat is 300 mg/kg, reflecting a toxicity higher than carbaryl (540 mg/kg) and trichlorfon (450 mg/kg). The 48-hour LC_{50} for rainbow trout is 0.45 ppm for Imidan, 4.38 ppm for carbaryl, and 3.2 ppm for trichlorfon. Imidan, like carbaryl, is highly toxic to bees (Stauffer, 1972; Pimentel, 1971). Imidan is considered not an alternative insecticide for use in suppression projects involving aerial application.

LEPTOPHOS (PHOSVEL(R))

Leptophos is a phosphonate insecticide which has been field tested against the gypsy moth. In tests by Stevens (1972)[1/] using concentrations of 1/4 and 1/8 lb active ingredient in one gallon of carrier per acre, leptophos provided foliage protection. At the 1/4 lb rate, there was a 4-10% increase in defoliation while at the 1/8 lb rate there was a 4-24% net increase in defoliation after spraying. The check plots had an increase in defoliation of 28-80% during the same time interval. Neither dosage rate provided population reduction, however, so populations in the treated areas had the potential to cause heavy defoliation the following year.

Leptophos has a high acute oral toxicity for rats: 52.8 mg/kg (male) or 42.9 mg/kg (female) (Velsicol, 1972). They reported leptophos gave 100% mortality to bees when applied at one lb active ingredient per acre. It is also quite toxic to rainbow trout, having an LC_{50} (96-hr) of 0.01 ppm.

The advantages of leptophos may include its minimal effects on some species of beneficial insects. Velsicol (1972) reported that leptophos left populations of two species of ladybird beetles relatively unaffected. It also was non-toxic to *Bathyplectes* spp. (Hymenoptera), predaceous Lygus bugs, damsel bugs, big-eyed bugs, and flower bugs. They report LD_{50}'s for mallard ducks of 17,244 mg/kg (female) and 19,052 mg/kg (male), which are very low. Another advantage may be its low application rate; it usually is applied at 1/4 or 1/8 lb active ingredient per acre.

Leptophos is not registered for control of the gypsy moth.

1/ Personal communication with L. J. Stevens, Gypsy Moth Methods Development Laboratory, APHIS, USDA, Otis Air Force Base, Mass.

METHOXYCHLOR

Methoxychlor is a chlorinated hydrocarbon insecticide currently registered for application against the gypsy moth from the ground by hydraulic sprayer or mistblower, but not for aerial application.

Tests exposing oysters and trout to concentrations of methoxychlor have shown high biological concentrations within the test animals (Pimentel, 1971). Oysters were exposed for 10 days to concentrations of 0.05 ppm in water; they concentrated the toxicant 5,780 times. The exposure of brook trout to methoxychlor at 0.005 ppm in water resulted in their accumulating an average of 1.759 ppm in 7 days.

Because methoxychlor has a high potential for biological concentration, it is not an alternative for aerial suppression projects.

ZECTRAN(R)

Zectran is a carbamate insecticide that has shown promise for controlling forest insects. It is currently registered for eastern spruce budworm, western spruce budworm, and the jack pine budworm. Zectran's dermal toxicity is very low - over 2,000 mg/kg for albino rabbits (Tucker and Crabtree, 1969) - and it has no vapor effect. Normal handling precautions are sufficient to safeguard those working with it. Utilizing protective clothing, gloves, respirators and showering will prevent mishaps to personnel who handle the material. Its low application rate, rapid degradation time, and low degree of cumulative toxic action also make it a favorable insecticide where human safety is important (Pimentel, 1971; Bollen et al., 1970; Pieper and Miskus, 1967).

The insecticide applied at very low rates (0.15 lb/acre), was as effective as malathion or DDT applied at one pound per acre to control the western spruce budworm (Buffam et al., 1967). In addition to the low dosage rate of application, Zectran has a very rapid breakdown into short-lived metabolites after application (Abdel-Wahab and Casida, 1967). Pieper and Miskus (1967) reported that residues of Zectran on Douglas-fir decreased rapidly after the first day of exposure. Mortality data on the western spruce budworm shows that effectiveness of Zectran ranged from 90% mortality at treatment, to only 7% mortality of budworm larvae 48 hours after application (Schmiege et al., 1970).

Zectran's adverse effects on the environment are minimal. Bollen et al. (1970) concluded that Zectran at the rates used for insect treatments has no adverse effects on microflora. No Zectran was found in water samples two weeks after application (Eichelberger and Lichtenberg, 1971). In studies of Zectran on fish and aquatic insects, several authors have concluded there would be little adverse effects on these populations (Graham, 1967; McCowan et al., 1967). Zectran is especially safe to fish, and was one of the least toxic chemicals tested on game fish by the U. S. Fish and Wildlife Service at their pesticide laboratory in Denver (USDI, 1965).

In field studies, no effects on caged eastern brook trout and no dead fish were taken in drift nets across the streams following application with Zectran (USDA, 1971b; McCowan et al., 1967; Peterson, 1968). Field tests have also indicated that Zectran has no adverse effects on bird populations in the spray areas (Peterson, 1968; Richmond and Pillmore, 1967; Mussehl and Schladweiler, 1969). Tucker and Crabtree (1969) concluded that Zectran, because of its low application rates, rapid degradation, and low degree of cumulative toxic action, should pose little hazard to wildlife under field conditions.

Zectran is not ready for operational use for gypsy moth control because, besides not being registered, these things about its use must first be determined: dosage rate, formulation, application method, timing, effects on the gypsy moth, and effects on non-target organisms in gypsy moth treatment areas.

WIDE-SCALE SPRAYING

Some persons consider that wide-scale spraying of total infested areas could be employed and that it would be a desirable alternative to the current policy of treating only localized high-value forested tracts and infestations of high risk for artificial spread. Reasons typically advanced are three : to end the outbreak, to eradicate the insect from North America, and to stop any further natural spread.

Our conclusion is that those objectives would not be met. Wide-scale spraying would fall short of its purposes for the combination of reasons that follow.

1.) The economic values at stake appear not to justify the required investment of dollars, equipment and manpower.

2.) Characteristics of current insecticides fall short of what would be required of them.

3.) Environmental trade-offs would most probably be judged unacceptable.

4.) Biological characteristics of the insect indicate an ability to survive such treatment and, probably in a short time, to pose the same problems again - possibly intensified.

5.) The public would succeed in excluding parts of designated areas from treatment.

6.) Such treatment is judged incompatible with what has been considered the soundest approach over-all : the present USDA long-range objective of achieving pest management through integrated means of control.

The high cost of treating entire outbreaks would be prohibitive for most of the States that undertake suppression of the gypsy moth. At the 1973 population levels, it would have required an outlay of at least ten times as much money to treat entire outbreak situations - even assuming that outbreak areas could be defined by visible defoliation. Many forested uninhabited areas do not economically justify any treatment costs. As an example of such areas, McCay and White (1973) illustrate that for a pulpwood stand examined in northeastern Pennsylvania, only $0.95 could be prudently spent on control measures if they eliminated all expected tree mortality. The current chemical and application costs for carbaryl or trichlorfon would be at least $5. per acre without including cost of project personnel. This, however, contrasts with a residential area where trees contribute an average of 7% and as much as 15% to the value of homes in the $25,000-$50,000. range (Payne et al., 1973). Rational pest control decisions require consideration of economic impact of pest attacks. Decisions for spraying massive areas are unacceptable today if they are based largely on hatred of the insect or similar emotions.

With any insecticide, it would be difficult to cause complete mortality of the gypsy moth. It would need a long residual life or repeated applications, because of the long period of egg hatching. It would have to be applied before any eggs hatch, to try preventing the escape of any caterpillars by dispersal from the target area. The insecticide's toxicity would have to be high enough to ensure killing every last caterpillar, or else survivors would shortly re-populate the area at high density levels. Complete mortality would be needed also to prevent the chance of developing populations of the gypsy moth resistant to insecticides, by allowing resistant caterpillars to survive and multiply. The insecticide would need to be highly specific for just the gypsy moth to avoid significant impacts on non-target organisms; survival of natural enemies of the gypsy moth would be desirable in case insecticide-caused mortality of the gypsy moth populations did not reach 100%. Finally, the insecticide and methods of applying it would need to be almost fool-proof, to compensate for inevitable human error and problems of application : drift, skips, temperature inversion, delayed operations, rain after spraying, dense foliage, etc. Mass control efforts have been attempted in the past, but usually surviving insects are able to perpetuate the populations, and to increase to previous population levels within 2-3 years (see, for example, Nichols, 1973). The logistical problems in treating large areas, together with limited treatment time available, make it unfeasible to treat massive infestations.

The effects of mass spraying would seriously upset biological forces of natural control, which normally help to limit the duration of an outbreak. Widespread spraying, therefore, might serve to perpetuate an infestation rather than suppress it. Spraying large areas would also have a measurable impact on non-target organisms and further contaminate our finite environment. Because every part of very large acreages would have to be treated, small impacts that would be insignificant by today's treatment methodology would be magnified. Instead of parts of small streams being inadvertently treated, for example, entire streams would be included (except obviously open water) and trees at the water's edge would not be excepted. Birds that easily fly beyond today's treatment areas for insect food they may find in short supply immediately after spraying would be hard pressed to either reach unsprayed areas or to find enough insects to feed on inside spray areas.

The biological characteristics of the gypsy moth make it very difficult to control. The protracted larval hatching period, early larval dispersal habits and high fecundity negate any hope of population eradication from a large area with currently available insecticides. As with all other species, the gypsy moth possesses systems to practically guarantee survival in environments contaminated with toxicants. Thus, widespread use of an insecticide that does not kill all exposed gypsy moth individuals should be expected to produce populations of the insect that are resistant to it. Practical elimination of parasites and predators, combined with a few surviving gypsy moths should be expected to result rapidly in a renewal of the gypsy moth problem - sooner than would be expected with natural control operating, and possibly by resistant populations. Nearly annual outbreaks could threaten unless nearly annual suppression campaigns were mounted.

Wide-scale spraying would have little or no hope of success if parts of the infested acreage were left untreated. Yet that exclusion of some acreage from treatment should be expected to happen, because there is some public resistance to large-scale use of insecticides, the application of insecticides from the air, harm to non-target organisms, and compliance forced by government agencies - particularly since the recent trend toward meaningful involvement of the public in government decision making.

The approach to the gypsy moth problem that is considered most hopeful by many persons experienced with the insect is integrated control. To manage the gypsy moth by this method would involve the monitoring of populations and the application of appropriate "pressures" at specific times and places. The "pressures" would include such things as virus, sophisticated insecticides, sex attractant, parasites, predators, and silvicultural practices.

Mass spraying is, therefore, not considered a viable alternative for the cooperative gypsy moth control programs.

BIOLOGICAL CONTROL

None of the following is thought to be a possible unilateral control material or method. Rather, each has a future role to play in a pest management system or in regulatory work.

> Nucleopolyhedrosis Virus. This is a major natural mortality agent of the gypsy moth in dense populations (Campbell and Podgwaite, 1971). Virus of the gypsy moth applied by ground equipment in a small field test reduced larval populations and resultant defoliation (Rollinson et al., 1965; Doane, 1970). Considerable safety data as well as efficacy data is being accumulated in preparation for registration.
>
> Formulation methods and delivery to the target organisms also require further work. Research by the Forest Service on this virus is continuing. The current estimate for obtaining registration is Fiscal Year 1975 (Lewis, 1971). The gypsy moth virus is not currently a useable alternative but has great promise as a segment of an integrated pest management system.

Sterile Moths. The sterile-moth release technique for gypsy moth control has been field-tested with inconclusive results (USDA, 1971a). It remains a possible means of eliminating the gypsy moth in isolated spot infestations, such as the periphery of the generally infested zone and in outlying areas. It might be regarded as a containment tool (USDA, 1971a).

Research has developed the technology for sterilizing the male insect by gamma radiation in the pupal stage. Refinement is needed to produce males really sterile and yet competitive with wild males (Godwin, 1966). Results from experimental field releases of these sterilized males have been limited and inconclusive. The sterile female has also recently been tried, by Statler (1970).

Considerably more research would be needed if sterile moths were to be used for widespread gypsy moth control. Patterns and techniques of release have not been determined; it is still not known how to space sterile moth releases, how many individuals must be released into wild populations, or how successful control would be in the long run, in view of an unchanged host-tree susceptibility. Techniques for efficiently rearing large numbers of insects are still lacking. Work on this basic problem is continuing.

Genetic Control. Control of the gypsy moth through the use of a "strong race" of males that have a high incidence of lethal factor genes was suggested by Goldschmidt (1934). Downes (1959) concluded that Goldschmidt's investigations covered most of the basic work needed. The approach would involve the introduction of a strong race from Japan and the release of strong-race males into small isolated or lightly infested areas. These males, crossed with American females, would produce as female progeny only hybrid individuals that are both sterile and intersexual (tending to female behavior, but rarely attracting a male). The hybrid male progeny, on the other hand, would be fertile. Mating with American females would produce among female progeny one-half that are sterile and intersexes. As desirable as these results seem, the technique also would mix the Japanese and American genes. The consequences of this need to be evaluated in extensive laboratory tests before field investigations begin. That laboratory work is in progress.

Genetic control cannot be considered an operational method today.

Sex Attractant. The sex attractant emitted by the female gypsy moth has been known previously but was recently identified and synthesized by Bierl et al. (1970).

Disparlure is a colorless liquid. Its solubility is 0.15 ppm in water at 25° centigrade, and it is soluble in organic solvents. Volatility at 25° degrees centigrade is slightly less than that of methyl palmitate.

Disparlure has been subjected to acute toxicity studies as a prerequisite to registration with the Environmental Protection Agency. In studies with albino rats, it has been determined that the acute oral LD_{50} for disparlure is more than 35,600 mg/kg; the acute dermal LD_{50} is more than 2,025 mg/kg. Eye and skin irritation tests with albino rabbits show that disparlure is not an irritant IBT,. 1972a, 1972b).

The value of disparlure, the synthetic attractant, as a detection tool has been established; it has been used exclusively, starting in 1971, in the annual detection survey programs. Its effectiveness has led to investigations of its possible use as a suppression tool. For example, a test at Dauphin Island, Alabama, indicated that male gypsy moths might be kept from finding females, thereby preventing the breeding of new generations (USDA, 1971a).

Among those working with disparlure, there is general agreement that the material is not likely to succeed as a suppression tool where gypsy moth population levels are high enough to cause even noticeable defoliation. But where they are detected before population increase or have been reduced to low levels by other agents of control, disparlure might reduce populations more and could conceivably eliminate the insect from some areas. Two methods are under investigation for developing disparlure as a suppression tool in very low-level populations of the gypsy moth.

Attraction is the key to the first method under investigation. It is based on traps baited with disparlure intercepting males before they can mate with females in an incipient population. In the theoretical success of the method reported by Beroza and Knipling (1972), traps introduced at the rate of 50 per female annually caused 94.6% "mating control" the first year and virtual elimination the third year. Testing that theory in 1972 revealed that current traps and current control over the release rate of the attractant are inadequate to the task. Mating in one instance was reduced up to one-third; at the other extreme it was increased nearly 120%. None of the reductions observed had biological significance (Cameron, 1973). A test to eradicate an isolated infestation by using attractant-baited traps apparently did not hold the population even static during 1971 and 1972 (Cameron, 1973).

Confusion is the key to the second method under investigation - confusion of male gypsy moths, that is. It is based on disrupting the chemical communication between adult females and males by volatilizing disparlure during the mating period from a carrier (such as granular cork or minute capsules) impregnated with the lure and released in the environment by aircraft. The disruption mechanism is not understood yet, but some insights have been gained (Richerson, 1972).

Tests have been conducted and reported by Stevens and Beroza (1972) and by Cameron (1973 and personal communication). Each of the test years 1971 and 1972 produced both encouragement to continue investigations and some frustration over unforeseen difficulties. Late in 1972 microencapsulated disparlure gave indications of promise. In 1973 expanded tests in Massachusetts and Pennsylvania showed that it reduced mating success of field populations - for 2 1/2 weeks in Massachusetts and up to 6 weeks in Pennsylvania. Testing revealed, too, that as a generalization, the more disparlure used, the better the disruption of mating; also, the lower the gypsy moth population, the better the results.

The fruitful investigations of 1973 have resulted in proposals to test disparlure in 1974 on populations already at low levels and on other populations brought to low population density by application of insecticide. In those tests disparlure as a 1-3% solution in xylene in a slow-release formulation (gelatine base or nylon-base microcapsules) would be applied by aircraft in an aqueous slurry at a rate of 2-10 g disparlure per acre. The aqueous phase of the formulation would include a sticker to fasten the microcapsules to leaves and a thickener to keep particles in suspension during spraying. Data from such tests is essential for improving concepts of containment and integrated control. Use of disparlure depends on knowledge of gypsy moth mating behavior, too, and that knowledge increased in 1973 (Richerson and Cameron, submitted for publication).

Parasites and Predators. During the past 100 years much effort has been devoted to the introduction of insect parasites and predators for the control of the gypsy moth. Close to 50 different species have been imported from Europe and Asia. Of these, eleven parasites (2 egg, 7 larval, and 2 pupal) and two predators have become established. In Pennsylvania, a State only recently experiencing outbreak numbers of the gypsy moth, a 1971 survey revealed that the gypsy moth's parasites also have immigrated to the State. Five species released originally in New England were recovered in the survey (Smilowitz and Rhodes, 1972). Establishment of effective parasites will contribute to an effective integrated control approach for gypsy moth.

The New Jersey Department of Agriculture[1] believes that information collected from its permanent woodland plots seems to show that parasites have a dampening effect following natural collapse of gypsy moth populations. The parasites contributing most to the possible stabilization are: *Parasetigena agilis*, *Sturmia scutellata*, *Apanteles melanoscelus* and *Compsilura concinnata*.

Recent interest in parasites has led to additional work in several agencies. The Parasite Introduction Branch, ARS, USDA, - with new, expanded facilities at Newark, Delaware - imports new parasites from Europe (increased emphasis will be placed on importation and evaluation of parasites from Japan) and sends them to the Division of Plant Industry, New Jersey Department of Agriculture. The New Jersey agency develops large-scale rearing methods for parasites, releases parasites in New Jersey, and provides colonies for APHIS. That Federal agency distributes starter colonies to some State agencies and releases some parasites at sites selected where male gypsy moths were trapped. Meanwhile, the Northeastern Forest Experiment Station, FS, USDA, has started an investigation of gypsy moth population dynamics designed to clarify and quantify, among other things, the contribution of parasites to natural control of the gypsy moth. How to use parasites effectively in an integrated approach to gypsy moth control should become clearer as that research progresses. One thing is clear : parasites alone can not now be used to achieve suppression of the gypsy moth.

1/ Letter from W. M. Cranstoun, N. J. Dep. Agr., to D. O. Vandenburg, NA-S&PF, FS, USDA, dated December 7, 1972.

Stand Manipulation. Silvicultural techniques have been suggested by various authors, but none yet has been proven effective or economical. Silvicultural control was proposed by Clement and Munroe (1917), Behre et al. (1936), Bess et al. (1947), and others. They advocated the removal of favored tree species, especially those of low commercial value, and encouragement of growth of species less preferred by the gypsy moth. The removal of old and injured trees with many bark flaps and branch stubs that provide favorable shelters for caterpillars was also proposed. These and other silvicultural approaches should reduce the damage of gypsy moth outbreaks, but no adequately documented tests have been conducted to date to evaluate these proposals. They remain practical proposals, though, because the techniques they call for coincide with practises needed to upgrade the management and protection of forested land. Private forest landowners can get advice and assistance on management and protection of their forests that would decrease forest susceptibility to the gypsy moth. That help can be gained in each State from consulting foresters, the State Forester, and the State's Extension Forester.

In surburban woodlands stand manipulation is feasible today. Less-preferred hosts could be encouraged or even planted. Common species in the Northeast include black walnut, white ash, catalpa, flowering dogwood, American holly, tulip-poplar, locust, sycamore, juniper, and balsam fir. In forests away from Suburbia stand modification would take much longer and is not suggested as an immediate solution to the dilemma (Clement and Nisbet, 1972).

INACTION

The effects of inaction on tree mortality and stand condition are described in detail in Part I (DESCRIPTION) of this Statement and are not repeated here. More immediate results of inaction involve the loss of both shade and appearance in defoliated areas. Caterpillars may be expected to create a nuisance in areas developed for human use. Doing nothing as an alternative to the proposed action would cause immediate results that are considered intolerable by the people who would be directly affected by the damage produced by the insect. Some individual property owners who consider values high enough and impending losses intolerable enough would, likely, pursue independent small-scale suppression measures involving a wide variety of chemical and mechanical methods.

Some possible disadvantages of a patchwork system of individual treatment efforts are:

- Less adherence to chemical application safety procedures.
- Application of larger amounts of chemicals; mistblowers, for example, may apply 10-15 pounds of insecticide per acre (EPA, 1972).
- Less efficient chemical application and reduced effectiveness.
- Need for multiple applications of chemical.
- Higher cost of ground application of chemicals.
- Variable effectiveness in the use of mechanical control measures (destruction of egg masses, for example, may be effective in isolated situations but of less value if a high insect population surrounds the area treated).
- Lack of knowledge about approved insecticides, proper equipment, and calibration techniques.
- Lack of expertise in knowledge of life history, biology, and natural control factors.
- Inadequate consideration of environmental impact.

ADDITIONAL ALTERNATIVES UNIQUE TO PROPOSED REGULATORY ACTIVITIES

The alternatives are:

1. Abandon regulatory aerial spray efforts and resort exclusively to mistblower ground applications. This procedure is undesirable from a regulatory and environmental standpoint for the following reasons. Ground applications with mistblowers are expensive, result in excessive dosages per tree or per acre and are limited in effectiveness due to the limited area which can be treated. Maneuverability of the larger sprayers in restricted roadways of typical parks, recreation areas, etc. permits treatment of only several hundred feet of woodland laterally from such sites. Where trees are tall, in excess of 50-70 feet, spray deposits for control may be inadequate. To reduce larval populations initially and maintain them at low levels for regulatory purposes, multiple applications, usually 2 or 3, are required. This typically results in application of 5-15 pounds of insecticide per acre.

In a study made June 21 to August 2, 1971, in an infested untreated private campground, all recreational vehicles (RV's) and associated equipment were examined for evidence of infestation. Departing RV's were recorded going to 20 States and Canada outside the regulated area. Evidence of infestation was recorded on 103 of 121 RV's inspected. Most RV's contained either mature larvae or pupae. Egg masses were located on only one vehicle and one tent. The pattern of movement of RV's from recreational areas is inconsistent, occurring at any hour of the day or day of the week. In the study noted above, 532 manhours of surveillance were required to intercept the 121 RV's of concern. The expense of such an effort extended to all such recreational areas scheduled for treatment in 1973 is prohibitive and, therefore, is an unacceptable alternative to aerial spraying. Experience has shown that the cost differential between aerial spraying and mistblower treatment ranges between \$3. - \$6. and \$15. - \$25. per acre respectively.

2. Revoke the Federal quarantine and permit the insect to spread unrestricted.

Either alternative would probably result in increased pesticide usage by the States and infested communities in the newly infested areas. Obviously, timber losses and the impact on recreation values would increase tremendously. Uninfested States now protected by the Federal quarantine could protect their interests by invoking restrictive trade barriers against the infested States, if the quarantine is revoked. The consequences of these alternatives are more adverse than the proposed action.

VII. IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES

As a result of carbaryl, trichlorfon, or *Bacillus thuringiensis* being applied to as little of the forest environment as necessary, it is not foreseen that there will be irreversible or irretrievable impacts on the environment. No plant or animal species, including the gypsy moth, is expected to be eradicated. All non-target species should recover from any damage and return to previous levels unless factors not associated with spraying intervene.

The human resources committed irretrievably are manpower and dollars. Not spent on the gypsy moth control and regulatory work, they would be available for alternative enterprises. The public apparently wants gypsy moth work to retain its current high priority.

VIII. CONSULTATION WITH OTHERS

This Draft Statement was prepared partly from current pertinent information requested from the State gypsy moth control agencies in New Jersey, New York, Pennsylvania, and Rhode Island; and from certain others who could provide up-dated information on particular subjects, including acephate, *Bacillus thuringiensis*, and disparlure. For the most part, though, this document is a revision made to update the Final Statement that was submitted March 28, 1973 for the 1973 gypsy moth suppression and regulatory program. As such, this Draft Statement embodies the wealth of knowledge acquired from consultation with the large number of agencies, groups, individuals, and organizations - private, commercial, State, and Federal - listed in the 1973 Final Statement (USDA, 1973).

Comments on this Draft Statement are solicited from those listed below, who will be sent copies after the Statement has been filed with the Council on Environmental Quality.

Robert M. Altman, Chief
Division of Plant Industries
State Department of Agriculture
University of Maryland
College Park, Maryland 20742

American Forestry Association
1319 18th Street, NW
Washington, D. C. 20036

John F. Anderson, State Entomologist
Connecticut Agricultural Experiment Station
Box 1106
New Haven, Connecticut 06504

Richard C. Back, Market Development Manager
Agricultural Products, Union Carbide Corporation
1730 Pennsylvania Avenue, NW
Washington, D. C. 2006

Robert Blanco
Environmental Impact Section
Environmental Protection Agency, Region III
Sixth and Walnut Streets, Curtis Bldg. 64
Philadelphia, Pennsylvania 19106

Adna R. Bond, Director
Maryland Forest Service
Towes State Office Building
580 Taylor Avenue
Annapolis, Maryland 21401

Peter Borrelli, Eastern Conservation
Representative, Sierra Club
250 West 57th Street, Suite 2017
New York, New York 10019

Edward A. Cameron, Asst. Prof.
Department of Entomology
106 Patterson Building
Pennsylvania State University
University Park, Pennsylvania 16802

G. Wallace Caulk, Secretary
State Department of Agriculture
Dover, Delaware 19901

Samuel S. Cobb, Director
Bureau of Forestry
State Department of Environmental Resources
P. O. Box 1467
Harrisburg, Pennsylvania 17120

Albert E. Cole, Director
Plant Pest Control Division
State Department of Agriculture
Charleston, West Virginia 25305

William M. Cranstoun, Director
Division of Plant Industry
State Department of Agriculture
P. O. Box 1888
Trenton, New Jersey 08625

Wallace Custard, State Forester
State Department of Conservation
and Economic Development
Division of Forestry
Charlottesville, Virginia 22903

Rudolph D'Andrea, Chief
Division of Agriculture
State Department of Natural Resources
Veterans Memorial Building
83 Park Street
Providence, Rhode Island 02903

T. E. Daw, State Forester
State Department of Natural Resources
Stevens T. Mason Building
Lansing, Michigan 48926

Henry J. Deion, Jr., State Forester
Division of Forest Environment
State Department of Natural Resources
Veterans Memorial Building
83 Park Street
Providence, Rhode Island 02903

Paul J. Eastman, Director
Division of Plant Industry
State Department of Agriculture
Augusta, Maine 04330

Dr. Roger O. Egeberg
Asst. Secretary for Health and Scientific Affairs
U. S. Department of Health, Education and Welfare
Washington, D. C. 20202

Alfred S. Elder, Director
Entomology Division, State Department of Agriculture
P. O. Box 2881
Raleigh, North Carolina 27611

Environmental Defense Fund
1910 N Street, NW
Washington, D. C. 20036

Andrew J. Forgash
Georges Road Laboratory
Department of Entomology and
Economic Zoology
Rutgers University
New Brunswick, New Jersey 08903

Dr. Sydney Galler, Deputy Asst. Secretary
for Environmental Affairs
U. S. Department of Commerce
Washington, D. C. 20230

C. F. Garner, Coordinator
Federal and State Projects
Research and Development
Chemagro Corporation
Box 4913, Hawthorn Road
Kansas City, Missouri 64120

Ernest J. Gebbhart, Chief
Division of Forests and Preserves
State Department of Natural Resources
Fountain Square, 1952 Belcher Drive
Columbus, Ohio 43224

Bruce S. Gullion, State Forester
State Department of Natural Resources
Leverett Saltonstall Building
100 Cambridge Street
Boston, Massachusetts 02202

W. M. Hoffman
Office of Pesticides Programs
Environmental Protection Agency
Washington, D. C. 20250

Fred E. Holt, Commissioner
State Department of Forestry
State Office Building
Augusta, Maine 04330

Jack O. Horton, Deputy Asst. Secretary
for Programs
U. S. Department of the Interior
Washington, D. C. 20240

Izaak Walton League of America
1326 Waukegan Road
Glenview, Illinois 60025

Peter C. Kuzmiski, Director
Division of Plant Pest Control
State Department of Agriculture
State Office Building, 100 Cambridge Street
Boston, Massachusetts 02202

Burel H. Lane, Director
Division of Plant Industry
State Department of Agriculture and Markets
Building 8, State Campus
Albany, New York 12226

Lowell V. Larson
Agricultural Chemicals Research
Agricultural & Veterinary Products Division
Abbott Laboratories
North Chicago, Illinois 60064

David E. Leonard
Department of Entomology
University of Maine
Orono, Maine 04473

Dean F. Lovitt, Chief
Division of Plant Industry
State Department of Agriculture
Lansing, Michigan 48913

Samuel V. Mace, State Forester
State Department of Natural Resources
and Environmental Control
William Penn and Legislative Avenue
Dover, Delaware 19901

Arthur M. Mason, State Entomologist
Insect and Plant Disease Suppression and Control
State Department of Agriculture
Nesmith Hall
Durham, New Hampshire 03824

W. Henry Matheny, State Entomologist
Division of Production and Industry Regulation
State Department of Agriculture and Commerce
P. O. Box 1163
Richmond, Virginia 23209

Lester McClung, State Forester
State Department of Natural Resources
State Office Building #3
Charleston, West Virginia 25305

John A. S. McGlennon, Regional Administrator
Environmental Protection Agency, Region I
Room 2303, John F. Kennedy Federal Building
Boston, Massachusetts 02203

George R. Moorhead, State Forester
Department of Environmental Protection
P. O. Box 1390
Trenton, New Jersey 08625

Caleb L. Morris, Chairman
National Gypsy Moth Advisory Committee
State Department of Conservation and
Economic Development
Division of Forestry, Box 3758
Charlottesville, Virginia 22903

National Association of State Foresters
Ralph Winkworth, Chairman
P. O. Box 27687
Raleigh, North Carolina 27611

National Wildlife Federation
1412 16th Street, NW
Washington, D. C. 20036

Theodore Natti, Director
Division of Resources Development
State Department of Resources
and Economic Development
State House Annex
Concord, New Hampshire 03301

Ian C. T. Nisbet, Assoc. Director
Scientific Staff
Massachusetts Audubon Society
Lincoln, Massachusetts 01773

Henry F. Nixon, Director
Bureau of Plant Industry
State Department of Agriculture
2301 North Cameron Street
Harrisburg, Pennsylvania 17120

Carl Paul
Environmental Impact Branch
Environmental Protection Agency, Region II
26 Federal Plaza
New York, New York 10007

Harold L. Porter, Chief
Division of Plant Industry
State Department of Agriculture
Reynoldsburg, Ohio 43069

James O. Preston, Director
Division of Lands and Forests
New York State Department of
Environmental Conservation
Albany, New York 12201

John W. Scott, Director
Division of Plant Pest Control
State Department of Agriculture
Montpelier, Vermont 05602

Society of American Foresters
1010 16th Street, NW
Washington, D. C. 20036

Elvis J. Stahr, President
National Audubon Society
1130 Fifth Avenue
New York, New York 10028

State Clearing Houses - Connecticut,
Delaware, Maine, Maryland, Massachusetts,
Michigan, New Hampshire, New Jersey, New York,
North Carolina, Ohio, Pennsylvania, Rhode Island,
Vermont, Virginia, West Virginia

U. S. Department of Agriculture:
Agricultural Research Service
Animal and Plant Health Inspection Service:

Plant Protection and Quarantine Programs:
P.O. Box 93
Moorestown, New Jersey 08057

Center Building
Hyattsville, Maryland 20782

South Building, 12th & Independence Ave., SW
Washington, D. C. 20250

Gypsy Moth Methods Development Laboratory
Building 268
Otis Air Force Base, Massachusetts 02542

U. S. Department of Agriculture
Forest Service

Chief's Office
South Building, 12th & Independence Ave., SW
Washington, D. C. 20250

Eastern Region
633 West Wisconsin Avenue
Milwaukee, Wisconsin 53203

Northeastern Forest Experiment Station
6816 Market Street
Upper Darby, Pennsylvania 19082

Pacific Southwest Forest & Range Experiment Station
Insecticide Evaluation Project
P. O. Box 245
Berkeley, California 94710

Southeastern Area, State & Private Forestery
1720 Peachtree Road, NW
Atlanta, Georgia 30309

Dr. William M. Upholt
Deputy Asst. Administrator for Pesticides Programs
Environmental Protection Agency
Washington, D. C. 20460

Edmund J. Vandermillen, State Forester
State Department of Environmental Protection
State Office Building, Room 260
165 Capitol Avenue
Hartford, Connecticut 06115

James E. Wilkinson, Jr., Director of Forests
State Department of Forests and Parks
Hill Side Building
Montpelier, Vermont 05602

Ralph Winkworth, State Forester
North Carolina Forest Service
P. O. Box 27687
Raleigh, North Carolina 27611

B. Witherspoon, Jr., Supervisor
Specialty Products Development
Chevron Chemical Company
940 Hensley Street
Richmond, California 94804

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X. GLOSSARY

Active ingredient (AI)
The effective part of the pesticide formulation, or the actual amount of the pesticide present in the formulation.

Acute toxicity
The toxicity of a compound when given in a single dose or in multiple doses over a period of 24 hours or less.

Apiary
A place where bees are kept.

Benthic organisms
The plants and animals at the bottom of a body of water.

Caddisfly
A small moth-like insect. The larvae live in fresh water in portable cases they construct around themselves. Member of order Trichoptera

Chronic toxicity
The effect of a compound on test animals when exposed to sublethal amounts continually.

Dosage rate
Quantity of a toxicant applied per unit (usually per acre).

Edema
An abnormal accumulation of fluid in cells, tissues, or cavities of the body, resulting in swelling.

Erythrocyte
A red blood cell.

Formulation
The form in which a pesticide is packaged or prepared for use.

EC_{50}
Median effective concentration, is the concentration (ppm or ppb) of the toxicant in the environment (usually water) which produces a designated effect to 50 percent of the test organisms exposed.

Frass
Solid larval insect excrement

Hymenoptera
A large order of insects, comprised of the ants, bees, sawflies and wasps. The typical adults each have four membranous wings and the chewing type of mouthparts.

Instar
The term for an insect before each of the molts (shedding of its skin) it must go through in order to increase in size. Upon hatching from its egg, an insect is in Instar I and is so called until it molts, when it begins Instar II, etc.

Larva (plural larvae)
An insect in the earliest stage of development, after it is hatched and before it is changed into a pupa; a caterpillar, maggot, or grub.

LC_{50}
Median lethal concentration, is the concentration (ppm or ppb) of a toxicant in the environment (usually water) which kills 50% of the test organisms exposed.

LD_{50}
Median lethal dose, is the milligram of toxicant per kilogram of body weight (mg/kg) lethal to 50% of the test animals to which it is administered under the conditions of the experiment.

Lepidoptera
A large order of insects, including the butterflies and moths, briefly characterized by four scale-covered wings and coiled sucking mouthparts.

Mg/kg
Milligrams per kilogram, is used to designate the amount of toxicant required per kilogram of body weight of test organisms to produce a designated effect, usually the amount necessary to kill 50% of the test animals. One mg/kg = 1 ppm. One mg = 0.000035 ounce, and 1 kg - 2.2 pounds.

Parasite

Any animal that lives in or on, or at the expense of another.

Polyphagous

Literally: "eating many". A term for an insect (or other animal) with the ability to survive on a wide variety of foods.

Predator

An animal that preys on others.

Ppb

Parts per billion is the number of parts of toxicant per billion parts of the substance in question. One ppb - 1 ug/liter (water or air).

Ppm

Parts per million is the number of parts of toxicant per million parts of the subject in question (1 ounce of salt in 65,500 lbs of sugar). One ppm - 1 mg/kg (on a weight basis) = 1 mg/liter (water or air).

Pupa (plural pupae)

The resting inactive instar in all holometabolous insects; the intermediate stage between the larva and the adult.

TL_m

TL_{50}

Median tolerance limit, is the concentration of toxicant which causes 50% mortality of a population under test conditions. It is usually expressed as parts per million.

XI. APPENDIX

1974 GYPSY MOTH SUPPRESSION PROGRAM
NEW JERSEY DEPT. OF AGRICULTURE

Objectives

Gypsy moth defoliation in New Jersey has been on an upward trend since 1965. Population reductions, brought about by both insecticides and biological control agents in some areas in the northern section of the State, have been offset by increased defoliation in the southern two-thirds of the State. Defoliation of one degree or another occurred on 255,000 acres during the spring of 1973. Of particular concern is the 59,000 acres of woodlands which suffered severe defoliation (70-100%). Realizing that the gypsy moth is well established in most sections of the State, the New Jersey Department of Agriculture has developed a pest management program which integrates both chemical and biological control. The program employs the use of short residual insecticides and biological control agents (parasites and predators) to reduce tree loss. The objective of the integrated control program is to prevent the loss of high valued trees in the residential and recreational areas of the State.

Treatment Priorities

Accordingly, the Department has classified the various woodland situations in the State and has established a list of priorities by which chemical treatment will be considered. The list, in order of importance, follows.

1. Forested communities with at least 20 homes per 100 acres, defoliated once or expecting heavy defoliation in 1974.

2. Municipal and County recreational areas defoliated once or expecting heavy defoliation in 1974.

3. Forested communities, with from 5-19 homes per 100 acres, defoliated once or expecting heavy defoliation in 1974.

4. Watershed areas defoliated once or expecting defoliation in 1974.

5. Uninhabited high-value forests defoliated once or expecting heavy defoliation in 1974.

The areas selected for treatment in 1974 are heavily infested. There is no indication that population collapses will occur in these areas. The only lands proposed for treatment are those residential and recreational lands where egg mass counts are over 500 per acre, 1973 pupal parasitism is less than 50% and severe defoliation is expected.

Biological Data

Experienced field personnel from the Division of Plant Industry are presently conducting gypsy moth egg mass surveys in all residential and recreational areas where requests for the inspection service have been made. At present, 117 communities have asked for this assistance. The survey, based on a modified plot system, classifies the various populations as being healthy, stressed, collapsed, and stable. The definitions of each of these categories follows.

Healthy

Egg mass numbers ranging from a few to 1,000 egg masses per acre. If old egg masses observed, numbers are less than new egg masses. The average egg mass is large or classified as half dollar size masses, sometimes quarter size. Pupae as located in bark niches measure 1 inch to 1 1/2 inches in length. The female-male pupal sex ratio favors female 6 to 4. Parasitism and predation of pupae is usually low, however, varying from 1-20%. Dehydration of pupae 0-3%. Diseased pupae varying from 0-10%.

Stressed

Egg mass number 1,000 plus per acre with more new masses than the previous year. The egg masses average nickel size. Pupae are small, averaging 3/4 inches in length. The female-male pupal sex ratio favors male 6 to 4. Parasitism and predation moderate, varying from 10-50%. Dehydration of pupae 3-10%. Disease of pupae varying from 10-30%.

Collapsed

Egg mass number less than 500 per acre with less new egg masses than found previous year. The egg masses average nickel and dime size. Pupae are small, averaging 3/4 inch or less in length. The female-male pupal sex ratio favors males 6 to 4. Parasitism and predation moderate to heavy varying from 20-80%. Dehydration of pupae 3-15%. Diseased pupae varying from 60-90%.

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Stable

Egg mass number less than 500 per acre. The egg masses average half dollar and quarter size. Pupae measure 1 inch to 1 1/2 inch in length. Female-male pupae sex ratio varies. Parasitism and predation moderate to heavy, varying from 30-70%. Dehydration of pupae varying from 0-3%. Diseased pupae varying from 5-20%.

In addition, other egg mass characteristics are also noted when there are indications that unusual conditions exist. Tree species and stand composition are compiled during the survey. All egg mass counts and stress or unusual conditions are carefully noted on both field and office survey maps (topographic maps, 1:24,000 scale). Treatment is only proposed for areas where egg mass counts are in the neighborhood of 500 plus per acre, parasitism and predation is low, the male-female ratio does not indicate a collapse situation and the percentage of disease and dehydration is low. Comparisons of the previous year's egg mass sizes and numbers are also utilized in establishing proposed treatment areas.

Of the 255,000 acres defoliated in 1973, it is presently estimated that 60,000 will require chemical control in 1974. Chemical control will be proposed for those areas which will be defoliated because of insufficient biological control activity.

Policy Statement

During the spring of 1973, the gypsy moth outbreak encompassed approximately 255,000 acres. Of significance is the fact that 59,000 acres were severely defoliated (70-100%), 45,000 acres less than that of 1972. It is expected the defoliation in the extreme northern portion of the State will decrease, but additional acreage in the central and north central sections of the State will increase. Data collected from aerial and ground surveys indicate that approximately 200,000 acres will be defoliated in 1974. Reduction of gypsy moth populations in the collapsed areas can generally be attributed to the excellent results of the integrated chemical-biological control program. A continuing program of chemical control will be necessary in the forested communities and high-use recreational areas where defoliation will occur in 1974. The careful and judicious use of short residual insecticides will protect our valued forest resources and will provide temporary relief until a more stabilizing influence can be attained by the biological agents.

Operational Plan

Generally speaking, the calendar of events which leads up to the actual application operation is as follows:

1. A Statewide aerial defoliation survey is conducted during early July. All defoliated acreages are categorized by severity, mapped and measured, by township (borough).

2. By mid-September, all local governments have been advised of the existing defoliation situation. At the same time, the Department offers the services of a gypsy moth egg mass survey (no fee). A survey request form is attached to the letter and must be submitted to the Department's office before a survey is performed.

3. The egg mass surveys are conducted during the winter months. Tree composition, male-female pupal ratios, pupal parasitism, and egg mass numbers and condition are also assessed at the time of the survey.

4. In areas where defoliation is expected to occur during the following spring, the local governments are requested to select representatives who will serve as spokesmen. Personnel from the Department meet with the various spokesmen, advise them of the infestation situation in their area, explain the type of program being implemented by the Department, and outline the various responsibilities of the participating governments.

5. The spokesmen return to the various local governing bodies and advise the local residents of the situation and the program. The local government then makes a decision as to whether or not they wish to enter into a cooperative control program.

6. Treatment areas are established through the mutual agreement of both the State and local governments. In order to meet State Statutes, several guidelines have been established in regard to proper notification of all occupants who reside on the lands selected for treatment. These guidelines have been reviewed by our Department's Deputy Attorney General. They are as follows:

(1) At least 10 days notice is required before treatment may begin.

(2) The notification contents should include the method of application, the material to be used, the intent of the program and the approximate time of application (example: mid to late May).

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(3) The notification can be delivered either personally or by registered mail (return receipt). If these two methods fail, a first class letter should be sent.

(4) If the notification is delivered personally, be certain that it is given to a responsible occupant (12 years of age or older).

Also, to remain within the frameworks of the State's Statutes, the local government must, by ordinance or resolution, declare that the gypsy moth is a public nuisance. (A model resolution may be found in the index.)

Contracts for aerial application are generally sent out to reputable applicators sometime during early April. Contracts are based on type and number of aircraft needed, treatment areas and acreage.

State personnel are assigned to work with the various contractors and personnel from the participating agencies. There is always at least one State employee assigned to each contract unit. It is that employee's responsibility to make certain that the contractor meets all the contract specifications and also to serve as an advisor to the local participating agency. In addition, the State also provides the aerial observers who are constantly checking the entire application operation and are in direct communication with local government personnel.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF FORESTRY
DIVISION OF FOREST PEST MANAGEMENT
Harrisburg, Pa. 17120

July 24, 1973

GUIDELINES FOR COUNTY-STATE-FEDERAL COOPERATIVE GYPSY MOTH CONTROL IN THE 1974 PROGRAM

The objective and purpose of this cooperative forest insect program is to provide tree foliage protection from gypsy moth defoliation in those populated and high-use areas of Pennsylvania where trees are valuable for recreational, aesthetic, and other purposes. A secondary objective is to provide relief to residents in forested areas from the serious public nuisance problem caused by massive invasions of migrating caterpillars. Treatments are thus restricted to areas highly used by the public and residents.

The Department of Environmental Resources will cooperate with county governments in efforts to reduce damage caused by the gypsy moth in these high-use, high-value, forested areas. Initially, in August the Department will provide the County Commissioners with detailed maps showing areas heavily infested by the insect, along with a preliminary indication of the problem to be expected in the following year.

The best method of coping with this insect on a statewide basis is through a cooperative coordinated program between the County, State, and Federal governments utilizing trained personnel. Individual or local group efforts have frequently resulted in unsuccessful operations, unnecessary treatments, over-dosages of insecticides, poor application timing, and environmental damage.

The following types of areas will be considered by DER for aerial control treatments under a State-supervised contract:

1.) Forested parks, recreational areas, campground, and special-use areas such as historic and natural sites, experimental forests, endangered croplands, and watershed areas surrounding public water supply reservoirs. Extent of watershed treatments will be decided by mutual agreement and available funds.

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2.) Forested communities and roadside strips in forested rural residential areas and containing at least two homes per 50 acres.

3.) Forested buffer zones, 200 to 500 feet wide, surrounding a community or other high-value area if a serious hazard is anticipated from caterpillars migrating from defoliated woodlands.

Areas excluded from consideration in chemical spraying programs include:

1.) Generally undeveloped and uninhabited forest lands. The treatment program is limited in scope, which is necessitated by current policy, available funds, operational factors, DER's biological control program, characteristics of spray materials available for use, and environmental constraints imposed on such programs. Reasons for not conducting massive chemical spraying programs are detailed in a separate document, which is available upon request.

2.) Villages, communities or other areas where the trees are scattered and accessible to feasible treatment by ground spraying equipment or by non-spraying methods as described in a separate leaflet. These are considered to be the responsibility of the property owner, or of the community.

3.) Areas where a biological collapse of the gypsy moth population can be expected so that serious tree defoliation and a public nuisance problem will not result. Generally, at least 500 healthy egg masses per acre must exist for a problem to develop.

4.) Generally, those areas less than 50 acres in size. There are exceptions made, but numerous small areas increase the costs and present operational problems.

5.) Areas where residents or property owners are opposed to having their property treated. Adjoining properties, or an entire spray block, may then have to be deleted if aircraft maneuverability or ground control landmarks become a problem.

6.) Any area that may be seriously harmed by the spray solutions or aircraft noise, as determined by the Department. DER will use safe application methods and non-persistent spray materials registered for use against the gypsy moth by the U. S. Environmental Protection Agency.

AGENCY RESPONSIBILITIES

County Participation.

DER will not include in a treatment program any of the considered areas, State-owned lands excepted, unless they are proposed by the County government. The scope of this problem has been increasing to the extent that DER cannot make the initial selection of treatment areas. Also, matters of this nature are best performed at the local level. Resident spraying requests received by DER are forwarded to the county for consideration.

The County government must perform the following steps in order to adequately fulfill their responsibilities:

1.) Appoint or hire a person to handle the local workload to coordinate activities with DER.

2.) Initiate a request for gypsy moth control assistance by October 15 if action is desired in the following year. This deadline is necessitated by Federal funding requirements.

3.) The request must be accompanied by a suitable map, scale 1 inch per mile or greater, on which are designated the general boundaries and acreages of areas where treatments are desired (other than State-owned land). Each treatment area should be at least 50 acres in size, but still only large enough to protect the resource. Include on a separate sheet of paper the characteristics of each proposed treatment area; such as name of area, average number of houses per 50 acres, whether houses are permanent or seasonal dwellings, average property values, major tree species, number of egg masses per acre, the general attitudes of people towards a control project, and any other information which may help the Department in its evaluation. This is also necessitated by Federal requirements and is included in the U. S. Department of Agriculture's Environmental Impact Statement.

4.) Send the Department copies of any pertinent correspondence, newspaper accounts, public meeting results, and similar information which will show the seriousness of the problem. Public meetings are encouraged to obtain an indication of the public sentiment towards a proposed project. DER personnel are available to assist and explain the program at these meetings.

5.) Upon notification that both DER and the U. S. Forest Service have accepted the proposals (probably in January and February), property owners in treatment areas must be notified of the impending project by certified mail or personal service. Those objecting within ten days of notification will have their property deleted. The Department will require the county to certify that proper resident notifications have been accomplished before any treatments will be made.

6.) Assist DER in its public relations endeavors in combatting the gypsy moth.

7.) Execute a contract with DER in which the county agrees to pay for 25% of the application costs. State and Federal agencies will share the remainder.

DER Participation.

After receiving the County request for cooperative control project, the Department shall:

1.) Examine each area proposed for treatment to determine, through a biological evaluation, the economic and biological soundness of the proposal.

2.) Determine feasible spraying boundaries consistent with aircraft performance and other factors.

3.) Conduct all phases of the control operations with U. S. Forest Service assistance; keep local officials informed of daily control operations and schedules.

Questions on these Guidelines may be directed to the Chief, Division of Forest Pest Management, at the Harrisburg Office, or to the local District Forester.

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Participation

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